Machine Intelligence and Robotics at Johnson Space Center Volume 2

AUTOMATION AND ROBOTICS DIVISION

ENGINEERING DIRECTORATE

NOVEMBER 1990

NASA

National Aeronautics and Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

AUTOMATION AND ROBOTICS DIVISION
NASA - LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS

MACHINE INTELLIGENCE AND ROBOTICS AT JOHNSON SPACE CENTER

VOLUME: 2

DOC. NO. JSC-24640 DATE 11/5/90

PREPARED BY:
Mary C. Ferguson
MARY C. FERGUSON, INTELLIGENT SYSTEMS BRANCH

APPROVED BY:
Kathleen J. Healey
KATHLEEN J. HEALEY, CHIEF, INTELLIGENT SYSTEMS BRANCH

APPROVED BY:
Jon D. Erickson
JON D. ERICKSON, CHIEF SCIENTIST, AUTOMATION AND ROBOTICS DIVISION

RELEASE AUTHORIZED BY:
W W Guy
WALTER W. GUY, CHIEF, AUTOMATION AND ROBOTICS DIVISION

DOC. NUMBER JSC-24640

JSC FORM 48 (AUG 90)

PREFACE TO VOLUME 2
ABOUT THIS REPORT

In late 1986, Aaron Cohen, the Center Director, asked to have information on projects at Johnson Space Center in automation and robotics collected and disseminated periodically. The organization that became the Automation and Robotics Division during a recent reorganization of Johnson Space Center assembled the information, compiled it into a report, and distributed it to the divisions of Johnson Space Center and other interested organizations. The process has been repeated about every six month since then. The chiefs of the JSC divisions doing technical work are asked for updated information about the projects in their divisions.

In 1989, the report was published in two volumes and given wide distribution. This report has a similar format: Volume 1 includes discussions of the National Space Policy of the United States as it relates to automation and robotics, the recent reorganization of Johnson Space Center, the JSC-Universities Consortium on Automation and Robotics, an overview of machine intelligence and robotics at Johnson Space Center, a discussion of the projects in machine intelligence and robotics at Johnson Space Center, and descriptions of the current status of the projects described in volume 1 of our report for FY89 (JSC1989). Volume 2 includes the information on all of the projects, organized by Division in the manner familiar from our previous reports. It is intended, again, that the two volumes should be complementary to each other and that each volume should be able to stand alone as a report of the information that it contains.

This report was prepared by Mary C. Ferguson of the Intelligent Systems Branch, from information provided by members of the Technical Divisions of Johnson Space Center. For information about this report call Mary Ferguson, ER2, NASA Johnson Space Center, (713) 483-2045. For information about the individual projects, call the person shown as point of contact.

CONTENTS

Section	Page
INTRODUCTION	1
PROJECTS REPORTED BY DA - ASSISTANT FOR ADVANCED PROJECTS	23
PROJECTS REPORTED BY DE - SPACE STATION SYSTEMS DIVISION	25
PROJECTS REPORTED BY DF - SYSTEMS DIVISION	27
PROJECTS REPORTED BY DH - OPERATIONS DIVISION	31
PROJECTS REPORTED BY DJ - SPACE STATION FREEDOM GROUND SYSTEMS	35
PROJECTS REPORTED BY EC - CREW AND THERMAL SYSTEMS DIVISION	41
PROJECTS REPORTED BY EE - TRACKING AND COMMUNICATIONS DIVISION	45
PROJECTS REPORTED BY EK - FLIGHT DATA SYSTEMS DIVISION	59
PROJECTS REPORTED BY ER - AUTOMATION AND ROBOTICS DIVISION	73
PROJECTS REPORTED BY ES - STRUCTURES AND MECHANICS DIVISION	163
PROJECTS REPORTED BY IA - NEW INITIATIVES OFFICE	169
PROJECTS REPORTED BY IC - TECHNOLOGY AND COMMERCIAL PROJECTS OFFICE	175
PROJECTS REPORTED BY NS - SAFETY DIVISION	177
PROJECTS REPORTED BY PT - INFORMATION TECHNOLOGY DIVISION	181
PROJECTS REPORTED BY SP - MAN-SYSTEMS DIVISION	251
GLOSSARY	263
ACRONYMS	265
REFERENCES	269
INDEX OF PROJECTS	271

TABLES

Table		Page
1	NUMBERS OF PROJECTS REPORTED BY EACH DIVISION	1
2	NASA CATEGORIES FOR WORK IN AUTOMATION AND ROBOTICS	5
3	NUMBER OF PROJECTS IN EACH OF THE PRIMARY CATEGORIES	2
4	TECHNOLOGY READINESS LEVELS OF PROJECTS AT JSC	2
5	PROJECTS THAT HAVE BEEN COMPLETED OR ARE IN USE	6
6	SYSTEMS BEING DEVELOPED	7
7	PROJECTS AT JSC LISTED BY PROGRAM AND KIND OF SYSTEM	9

FIGURES

Figure		Page
1	Request for information on projects in automation and robotics at JSC	4

Title	Number	Page
Projects reported by DF – Systems Division		
Shuttle INCO expert system/real time data system	190-96	28
Projects reported by DH – Operations Division		
System management applications	190-87	32
Projects reported by DJ – Space Station Freedom Ground Systems		
Transition Flight Control Room enhancement	190-21	38
Projects reported by EE – Tracking and Communication Division		
Control system use of optical correlator vision	190-72	54
Image remapping	190-73	46
Projects reported by EK – Flight Data Systems		
ACES – Analysis criteria evaluation system	190-97	62
Projects reported by ER – Automation and Robotics Division		
Architectures for semi-autonomous planning	190-57	88
Automated robotic assembly of Space Station	190-144	80
Autonomous lander for planetary exploration	190-64	94
CONFIG: Qualitative and discrete event fault management analysis tools	190-64	104
Control architecture for autonomous robotics	190-60	160
Definition of advanced automation testbed requirements	190-52	146
Design knowledge capture	190-53	86
Diagnostic reasoner/recovery expert	190-90	112
EVA retriever central software	190-56	148
EVA retriever ground demonstration	190-66	98
EVA retriever testbed	190-47	120
EVA retriever vision/tracking system	190-78	126
Expert system for execution of crew procedures	190-70	102
Human interface with intelligent fault management systems	190-85	106
Robotic vision/tracking sensors	190-77	124
Smart electromechanical attenuator/actuator for SS docking/berthing	190-136	136
Space Station health exercise monitoring and control system	190-59	92
Structural assembly, berthing, and manufacturing support	190-139	140
Task level robot programming for EVA retriever simulation	190-61	152
Verification and validation of rule-based systems	190-138	138
Vision for the EVA retriever	190-62	154

Projects reported by ES – Structures and Mechanics Division

Long reach latch development	190-118	164
Payload installation and deployment aid (PIDA)	190-125	166

Projects reported by IA – New Initatives Office

Demonstration of magnetic attachment tool and magnetic end effector	190-26	172
Dexterous manipulator demonstration flight experiment	190-25	170

Projects reported by PT – Information Technology Division

AI section/man-machine interfaces	190-6	218
Automatic perception for NASA mission planning and flight control	190-9	212
C language integrated production system (CLIPS)	190-24	216
Develop neural network computer system	190-7	220
Develop and experimentation of eye/brain/task test bed	190-8	248
Development of an ada-based version of ART	190-12	200
Onboard navigation expert system	190-81	224
Payload-assist module deploy/intelligent computer-aided training system	190-79	210

Projects reported by SP – Man-Systems Division

Interface to advanced display, control, and computer technologies	190-13	252
Man and robot motion modeling	190-19	258
Telerobotic servicer man-systems integration and testing	190-14	260

INTRODUCTION

In response to our request, at the beginning of FY90, for information about projects at JSC in machine intelligence and robotics, we received information about 158 projects from 15 divisions, listed in Table 1.

TABLE 1.- NUMBERS OF PROJECTS REPORTED BY EACH DIVISION

Division	Code	Number of Projects
Assistant for Advanced Projects	DA	1
Space Station Systems	DE	1
Systems	DF	1
Operations	DH	1
Space Station Freedom Ground Systems	DJ	2
Crew and Thermal Systems	EC	3
Tracking and Communications	EE	9
Flight Data Systems	EK	10
Automation and Robotics	ER	61
Structures and Mechanics	ES	2
New Initiatives Office	IA	2
Technology and Commercial Projects Office	IC	1
Safety	NS	2
Information Technology	PT	55
Man-Systems	SP	7

Funding for projects at JSC in machine intelligence and robotics has increased dramatically for FY90. Of the 158 projects that we know about, 97 (79 percent of the projects that are active, continuing at a low level of effort, or in use) are funded. A total of over $17 million per year is accounted for by the projects for FY90 that are funded at over $100 thousand each. The funding for FY90 is almost twice that for previous years; in FY87 and FY88 the total funding for all projects was over $10 million; in FY89 it was over $11 million. For FY90, 73 percent of the projects that are funded account for 94 percent of the total funding of almost $19 million for the fiscal year.

The organization of the data base of the projects, and the data base management system used for storing the information is described in volume 2 of our report for FY89 (JSC1989).

Figure 1 is the form for reporting information about projects in Automation and Robotics. Each project is characterized in two ways: by the NASA categories describing the work of the project, and by the level of technological readiness. Table 2 is the list of NASA categories; the levels of technological readiness are included in Figure 1 at the lower right.

The NASA categories in Table 2 are divided into two groups: basic functional capabilities and systems capabilities. Table 3, for the projects that are active, proceeding at a low level of effort, or are in use, gives the number of projects in each category.

Information on Projects in Automation and Robotics at Johnson Space Center

Title:

Program	NASA Hq.Program Code: (Ex: MD, RC)	UPN/UPC (if any)	Task No.	Date

Point of Contact Telephone	Division	Branch	Section

Check if appropriate: __ Products completed __ Task inactive __ Products are in use __Task continues at a low level of effort

Please use the attached list to identify up to 6 categories that describe the work of the project:

FUNDED ☐ **YES** ☐ **NO** TOTAL OF NEW OBLIGATIONS THIS FISCAL YEAR _____K$ Contract funds _____ K$ In-House funds _____ K$

EQUIVALENT NUMBER OF EMPLOYEES: Contractor_____, Civil Service____

Performing organizations, other than JSC	Name of contact	Telephone
1	1	1
2	2	2
3	3	3

Description, including planned activity and end products:

Current Status:

Schedule, including missions supported

Expected level of technology at the end of the fiscal year

Please circle one

Level	Definition
1	Basic Principal observed or reported
2	Conceptual Design Formulated
3	Conceptual Design Tested
4	Critical Function or Characteristic Demonstrated
5	Component or Breadboard Tested in the Relevant Environment
6	Prototype or Engineering Model Tested in Relevant Environment
7	Engineering Model Tested in Space or Operational Environment
8	Full Operational Capability

Figure 1.- Request for information in automation and robotics at JSC.

TABLE 2.- NASA CATEGORIES FOR WORK IN AUTOMATION AND ROBOTICS*

Basic Functional Capabilities

1.1 Knowledge

1 acquisition of knowledge
2 control methods
3 deduction and theorem proving
4 diagnosis
5 execution
6 learning
7 monitoring
8 perceptual reasoning
9 planning
10 problem solving
11 recognition of objects
12 representation and reasoning
13 search techniques
14 simulation

1.2 Sensing

1 auditory and acoustic
2 coding of sensor information
3 current and voltage
4 dewpoint
5 flow
6 flow rate
7 force and torque
8 integrating sensor information
9 pressure
10 proximity
11 range and rate
12 tactile and kinesthetic
13 temperature
14 visual and optical

1.3 Actuation and manipulation

1 actuation in expert systems
2 arms
3 collision avoidance
4 compliance
5 control technology
6 coordination
7 end effectors
8 manipulators
9 propelling mechanisms
10 recovery from errors

1.4 Human/machine interface

1 controls
2 displays
3 feedback of force and torque
4 fusion of information from sensors
5 input mechanisms
6 interfaces to knowledge based or expert systems
7 management of user interfaces
8 maintenance of interfaces
9 options for levels of automation
10 processing of natural language
11 reprogramming interfaces
12 tradeoffs for automation
13 voice recognition
14 voice synthesis

System Capabilities

2.1 Supporting software and hardware

1 accommodation for automation & robotics in design
2 distributed systems
3 fault-tolerant architecture
4 management of resources
5 programming languages
6 specialized architecture for artificial intelligence
7 uninterruptable systems

2.2 System design and integration

1 aids for documentation
2 aids for design
3 aids for programming
4 automated software development
5 automatic checkout and test
6 automation of engineering
7 environments for automation
8 knowledge engineering
9 shells for knowledge based or expert systems
10 validation and verification

2.3 Knowledge based or expert systems

1 control
2 data base management
3 distributed expert systems
4 engineering support
5 executives for expert systems
6 hybrid expert systems
7 interacting expert systems
8 management of faults
9 monitoring
10 planning
11 programming support
12 scheduling
13 sequencing
14 servicing and repair
15 retrieval and rescue

2.4 Robotic and telerobotic systems

1 assembly
2 automatic inspection
3 computer vision systems
4 construction
5 handling of parts
6 servicing and repair
7 retrieval and rescue

*Appendix F, ATAC Progress Report 3, NASA Technical Memorandum 89190, Oct. 1, 1986. Subcategories have been alphabetized and numbered.

This page intentionally left blank

TABLE 3.- NUMBER OF PROJECTS IN EACH OF THE PRIMARY CATEGORIES

Category		Number of projects	
1.1	Knowledge	18	15%
1.2	Sensing	6	5%
1.3	Actuation and Manipulation	16	13%
1.4	Human-Machine Interface	15	12%
2.1	Supporting Software and Hardware	9	7%
2.2	System Design and Integration	15	12%
2.3	Knowledge Based or Expert Systems	27	22%
2.4	Robotic and Telerobotic Systems	17	14%

The categories for basic functional capabilities describe 45 percent of the projects. The categories for systems capabilities describe 55 percent. Six categories, each with 12 percent or more of the projects, describe 88 percent of the work. Almost one-fourth of the projects are work on knowledge based or expert systems.

Table 4, for projects that are active, proceeding at a low level of effort, or are in use, shows the number of projects expected to be in each of the technology readiness levels at the end of FY90.

TABLE 4.- TECHNOLOGICAL READINESS OF PROJECTS AT JSC

Level of Technological Readiness		Number of Projects	
1	Basic principle observed or reported.	7	6%
2	Conceptual design formulated	10	8%
3	Conceptual design tested analytically or experimentally	12	10%
4	Critical function or characteristic demonstrated	35	28%
5	Component or breadboard test in the relevant environment	13	11%
6	Prototype or engineering model tested in the relevant environment	26	21%
7	Engineering model tested in space or the operational environment	1	1%
8	Full operational capability (incorporated in production design)	11	9%
Not given		8	7%

Almost 50 percent of the projects are expected to be in two of the technological readiness levels by the end of the current fiscal year: 4 - critical function or characteristic demonstrated, and 6 - prototype or engineering model tested in the relevant environment. Forty-one percent of the projects are expected to be in technology levels 5 through 8 by the end of this fiscal year.

Fifteen projects base have been completed or are in use. Table 5 lists them by technology level and category. Projects expected to be in technology levels below 6 that are shown as completed either contribute to a larger project, or are a part of a project that has been discontinued.

TABLE 5.- PROJECTS THAT HAVE BEEN COMPLETED OR ARE IN USE

Projects that have been completed

Technology level expected at the end of the fiscal year, NASA category, division code, and title

2 2.3 ER Definition of Advanced Automation Testbed Requirements

3 1.3 ER Algorithm for Using Multiple Manipulator Arms to Control a Payload

4 1.4 PT Development and Experimentation of Eye/Brain/Task Test Bed

6 1.1 PT The Use of Fuzzy Set Theory in Controlling Failures in Space Systems
6 2.3 EC Thermal Expert System (TEXSYS) for Control and Fault Diagnosis
6 2.4 PT Greyscale Morphology in Machine Vision

8 1.4 ER Advanced Graphics Laboratory Systems Development
8 1.4 ER Enhancement of Simulation/Animation Graphics System

Projects that are in use

Technology level expected at the end of the fiscal year, NASA category, division code, and title

5 2.2 EK RDIA – Requirements Decision Impact Assessment

6 2.2 SP Man and Robot Motion Modeling
6 2.4 IA Dexterous Manipulator Demonstration Flight Experiment

8 1.3 ER Robotic Gripper Controller Development
8 2.2 PT C Language Integrated Production System (CLIPS)
8 2.3 DF Shuttle INCO Expert System/Real Time Data System
8 2.3 EK QUEST – Quality Expert System Tool

Eleven projects in Table 5 are expected to be in technology levels 6 or 8 at the end of FY90: 6 in technology level 8, and 5 in technology level 6. Volume 1 includes a list of those projects, in Appendix C, with a description of each project and its history as recorded in our data base.

Our information for FY90 includes 18 projects that have been changed since our last report, 8 have been completed, 7 are in use, 106 are active, and 16 continue at a low level of activity; 97 are funded, 17 are new to our data base, and, mainly because of the reorganization, 130 have been changed to a new division. 12 projects are shown as inactive and 11 have been discontinued since our last report. One of the projects shown as discontinued is being used. The 106 projects shown as active are being worked on full time. Those plus the 16 shown as continuing at a low level of effort make a total of 122 projects that are currently being worked on.

Five projects that were identified as separate projects in our report for FY89 have now been incorporated into another project. They are included in our current data base for continuity, and will be dropped when updated information is collected. When the originators of a project report it to be inactive, it is kept in the data base until the originators indicate that it has either been reactivated or discontinued. Projects shown as completed or discontinued remain in

the data base for the next period, for continuity, then are dropped unless the originators indicate that work on the project is continuing.

Projects included in the data base are each identified in several different ways in addition to those discussed above: by categories describing the purpose of the project (e.g., design, knowledge based prototype), and the kind of system being developed; and by the program to which the project applies (Shuttle, Space Station, or Advanced Programs) as in the following table.

TABLE 6.- SYSTEMS BEING DEVELOPED

Shuttle

- Computer Aided Training
- Intelligent Interfaces
- Intelligent Systems for Use on the Ground
- Intelligent Systems for Use in Space
- Manipulators

Space Station

- Automation and Robotics Safety
- Design Knowledge Capture
- Dexterous Manipulator
- Flight Telerobotic Servicer
- Intelligent Interfaces
- Intelligent Systems for Use on the Ground
- Intelligent Systems for Use in Space
- Intelligent Systems for Use in Space and on the Ground
- Robotics for Use in Space.

Advanced Programs

- Autonomous Lander
- Computer Aided Training
- Computer Vision
- Dexterous Manipulator
- EVA Retriever
- Intelligent Interfaces
- Intelligent Systems for Use in Space
- Intelligent Systems for Use in Space and on the Ground
- Modeling the Motion of Man and Robot
- Neural Computers
- Robotics for use on the Ground
- Robotics for use in Space
- Systems Autonomy Demonstration Project
- Systems for Development of Intelligent Software
- Systems Using Intelligent Hardware
- Systems Using Qualitative Modeling

All of the projects are listed in Table 7, classified as above. Projects for which expanded writeups are given in Volume 1 are marked with asterisks. This table appears as Appendix D in Volume 1.

When information returned about a project indicates that it has been completed or discontinued, it is retained in the data base and included in the next report of the contents, to provide continuity of information about the project. When the next report is generated, if the state of the project has not changed, it is dropped from the data base for the next reporting period. Projects reported as being inactive are retained in the data base until the reporting organization indicates that the state has been changed.

The information on the projects that follows is organized by Division, and presented in the order of the Division codes. The first page for each Division is a title page that contains a summary of information about the projects in that Division and an index of the projects. The summary shows the the number of projects in each of the NASA Categories, the number of projects expected to be at each technology level at the end of FY90 the total number of projects, and the sum of funds. The index lists the projects, by title, in alphabetical order, with the project number and page on which it is found. Information on the projects reported by the Division follows.

TABLE 7.- PROJECTS AT JSC LISTED BY PROGRAM AND KIND OF SYSTEM

SPACE SHUTTLE

Title	Division	Number	State	Page
Computer-Aided Training				
Instrument Pointing System/Intelligent Computer Aided Training System	PT	190-115	Active	199
Main Propulsion Pneumatics/Intelligent Computer-Aided Training System	PT	190-112	Active	196
* Payload-Assist Module Deploy/Intelligent Computer-Aided Training System	PT	190-79	Active	211
Projects that are not active				
Intelligent Computer-Aided Training (ICAT)	PT	190-158	in 190-79	237
Intelligent Computer Aided Training System for PAM Deploys	PT	190-157	in 190-79	235
Intelligent Interfaces				
AI Section/Man-Machine Interfaces	PT	190-6	Active	219
Phoneme Based Speech Recognition for Mission Planning and Control	PT	190-10	Active	183
Intelligent Systems for use on the Ground				
* ACES – Analysis Criteria Evaluation System	EK	190-97	Active	63
AutoLib (Automated on-line Library)	PT	190-105	Active	188
Automation and Expert System Applications for Planning and Scheduling	PT	190-30	Active	204
Automated Ground Systems Status/Control	DJ	190-20	Active	37
Computer Aided Software Engineering (CASE) Tools Review and Evaluation	PT	190-103	Active	186
DASHES – Dump Analysis for Simulator/Hardware Expert System	EK	190-98	Active	64
Intelligent Evaluation System for Simulator Training	PT	190-114	Active	198

This page intentionally left blank.

Title	Division	Number	State	Page
LATEST – Launch Countdown Anomaly using Expert Systems Technology	EK	190-99	Active	65
Mission Evaluation Room Advanced Automation Project (MAAP)	ER	190-135	Active	135
Operations Process Model	DA	190-146	Active	24
Software Reengineering/Reuse	PT	190-107	Active	190
Support Technologies Development	PT	190-51	Active	209
Projects that continue at a low level of effort or are not active				
QUEST – Quality Expert System Tool	EK	190-100	low level, in use	61
RDIA – Requirements Decision Impact Assessment	EK	190-150	discontinued, in use	71
SHADES – Shuttle AP-101 Diagnostic Expert System	EK	190-148	inactive	69
SILES – Shuttle I-Load Expert System	EK	190-147	inactive	68
Intelligent Systems for use in Space				
Expert System for Execution of Crew Procedures	ER	190-70	Active	103
On-Board Navigation Expert System	PT	190-81	Active	225
Projects that continue at a low level of effort or are not active				
Expert System for Shuttle Electrical Power Management	PT	190-55	inactive	247
Payload Installation and Deployment Aid (PIDA)	ES	190-125	low level	167
Procedural Reasoning System	ER	190-71	discontinued	158
SPLINTER – SpaceLab Integration	EK	190-149	discontinued	70
The Use of Fuzzy Set Theory in Controlling Failures in Space Systems	PT	190-37	completed	241
Manipulators				
Advanced Force/Torque Control Study for the RMS System	ER	190-123	Active	77
Automated Grappling Control for the Shuttle RMS	PT	190-31	Active	205
* Dexterous Manipulator Demonstration Flight Experiment	IA	190-25	Active, in use	171
RMS Advanced Closed Loop Control	ER	190-65	Active	97

This page intentionally left blank.

Title	Division	Number	State	Page
Automation and Robotics Safety				
Artificial Intelligence and Robotics Flight Safety	NS	190-2	low level	179
Artificial Intelligence and Robotics Ground Safety	NS	190-1	low level	178
Design Knowledge Capture				
Design Knowledge Capture	ER	190-53	Active	87
Projects that are not active				
Functional Area Manager for Design Knowledge Capture	ER	190-22	in 190-53	142
Dexterous Manipulator				
Demonstration of Magnetic Attachment Tool and Magnetic End Effector	IA	190-26	Active	173
Dual Actuator Robotic Joint Mechanism	ER	190-121	Active	76
Projects that are not active				
Algorithm for Using Multiple Manipulator Arms to Control a Payload	ER	190-67	completed	157
Flight Telerobotic Servicer				
FTS/WP-2 Accommodations Issues Task	EC	190-42	Active	42
Orbiter and Space Station Control Station Breadboard	ER	190-82	Active	128
Space Station Assembly Task Identification and Assessment	EC	190-43	Active	43

Title	Division	Number	State	Page
Projects that continue at a low level of effort or are not active				
Model and Simulation for FTS Control Station Testbed and Brassboard	ER	190-83	low level	159
Telerobotic Servicer Man-Systems Integration and Testing	SP	190-14	discontinued	261
Intelligent Interfaces				
Space Station Program Human-Computer Interface Guide and Standards	SP	190-16	Active	255
Space Station Workstation System	SP	190-17	Active	256
Intelligent Systems for use on the Ground				
Advanced Automation Methodology Project	ER	190-88	Active	109
Electrolysis Fault Diagnosis Expert System	ER	190-94	Active	161
Shuttle INCO Expert System/Real Time Data System	DF	190-96	Active, in use	29
Software Cost Modeling and Automated Data Collection	PT	190-110	Active, operational	194
* Transition Flight Control Room Enhancement	DJ	190-21	Active	39
Projects that are not active				
Automation Test Bed	EK	190-126	inactive	66
Real-Time Garbage Collection	EK	190-130	inactive	67
Space Station Mission Requirements Data Bases	PT	190-54	inactive	246
Intelligent Systems for use in Space				
* Active Thermal Control System – Simulation and Fault Management	ER	190-92	Active	115
Advanced Automation Network Monitoring System	ER	190-89	Active	111
An Automatic Assistant for Scheduling and Planning for the Space Station	PT	190-29	Active	226

Title	Division	Number	State	Page
Diagnostic Reasoner/Recovery Expert	ER	190-90	Active	113
Space Station Health Exercise Monitoring and Control System	ER	190-59	Active	93
Space Station Operations Management System	ER	190-137	Active	79
* System Management Applications	DH	190-87	Active	33
Projects that continue at a low level of effort or are not active				
Automated Antenna Management	EE	190-152	low level	51
Automated Resource Manager	EE	190-153	low level	52
Definition of Advanced Automation Testbed Requirements	ER	190-52	completed	147
Long Reach Latch Development	ES	190-118	inactive	165
Override Demonstration	ER	190-129	discontinued	131
On-Orbit Maintenance	DE	190-145	low level	25
Intelligent Systems for use in Space and on the Ground				
Functional Area Manager for Work Package 2 Advanced Automation	ER	190-91	Active	114
SERC/PCEE	PT	190-109	Active	192
Projects that are not active				
Vision for Grasping for EVA Retriever	ER	190-63	discontinued	156
Robotics for use in Space				
Automated Robotic Assembly of Space Station	ER	190-144	Active	81
Projects that are not active				
Structural Assembly, Berthing, and Manufacturing Support	ER	190-139	inactive	141
Smart Electromechanical Attenuator/Actuator for SS Docking/Berthing	ER	190-136	discontinued	137

ADVANCED PROGRAMS

Title	Division	Number	State	Page
Autonomous Lander				
* Autonomous Lander for Planetary Exploration	ER	190-64	Active	95
Computer Aided Training				
An Intelligent Tutoring System for High School Physics	PT	190-113	Active	197
Computer Vision				
Computer Graphics Testbed for Vision Systems to be Used in Space	PT	190-38	Active	207
Control System Use of Optical Correlator Vision	EE	190-72	Active	55
Correlation-Based Synthetic Discriminate Filter for Image Segmentation	PT	190-140	Active	230
Demonstration of a 3D Vision Algorithm for Space Applications	PT	190-39	Active	227
Fuzzy Ring Network for Machine Vision	PT	190-142	Active	232
Image Remapping	EE	190-73	Active	47
Machine Vision using Artificial Neural Network Simulations	PT	190-32	Active	206
Programmable 3D Range/Doppler Imagine Ladar	EE	190-75	Active	48
Projects that are not active				
Greyscale Morphology in Machine Vision	PT	190-35	completed	240
Hybrid Vision Laboratory	EE	190-119	inactive	56
Dexterous Manipulator				
Dynamic Modeling of 6+ DOF Robotic Manipulator Systems	ER	190-156	Active	84
Redundant Manipulator Kinematics	ER	190-155	Active	83

Title	Division	Number	State	Page
EVA Retriever				
Architectures for Semi-Autonomous Planning	ER	190-57	Active	89
Connected Autonomous Neural Sight-Arm System (CANSAS)	ER	190-95	Active	162
EVA Retriever Central Software	ER	190-56	Active	149
EVA Retriever Ground Demonstration	ER	190-66	Active	99
EVA Retriever Test Bed	ER	190-47	Active	121
EVA Retriever Vision/Tracking System	ER	190-78	Active	127
Free-Flyer/ Fault Detection and Correction system	ER	190-46	Active	119
Free-Flyer/Robotic Arm Positioning Techniques	ER	190-45	Active	117
Smart Robotic Hand for EVA Operations	ER	190-44	Active	116
Vision for the EVA Retriever	ER	190-62	Active	155
Projects that are not active				
Autonomous Object Recognition for the EVA Retriever	PT	190-50	inactive	245
Task Level Robot Programming for EVA Retriever Simulation	ER	190-61	discontinued	153
Intelligent Interfaces				
Biodynamic Checklist Processing	SP	190-15	Active	
Helmet Mounted Display System	ER	190-131	Active	132
Human Interface with Intelligent Fault Management Systems	ER	190-85	Active	107
Interface to Advanced Display, Control, and Computer Technologies	SP	190-13	Active	
Intelligent Assistants Technology – Human Interface Guidelines	ER	190-86	Active	108
Remapping for Low Vision	EE	190-74	Active	57
SIM Tool	PT	190-106	Active	189
Operator Cognitive Modeling	SP	190-18	Active	

Title	Division	Number	State	Page
Projects that are not active				
Advanced Graphics Laboratory Systems Development	ER	190-132	completed	133
Development and Experimentation of Eye/Brain/Task Test Bed	PT	190-8	completed	249
Enhancement of Simulation/Animation Graphics System	ER	190-133	completed	134
Intelligent Systems for use in Space				
Adaptive Fuzzy Logic Control	PT	190-134	Active	202
Intelligent Systems for use in Space and on the Ground				
Automated Fault Isolation by Bit Strings	EE	190-151	low level	50
Modeling the Motion of Man and Robot				
Man and Robot Motion Modeling	SP	190-19	Active, in use	259
Neural Computers				
A Back Propagation Simulator for the Hypercube	PT	190-128	Active	229
An Accelerated Method for Back Propagation Networks	PT	190-141	Active	231
Projects that continue at a low level of effort				
A Difference Optimized Training Scheme for the Neocognitron	PT	190-143	low level	233
A Neural Network Based Technique for IR Spectral Analysis	PT	190-127	low level	228
NETS: A Tool for the Development and Delivery of Neural Networks	PT	190-4	low level	242

Title	Division	Number	State	Page
Robotics for use on the Ground				
Robotic Arms for Manipulating Equipment During Thermal Vacuum Tests	ER	190-48	inactive	145
Robotics for use in Space				
Advanced Development for Space Robotics	ER	190-68	Active	101
A Unified Robotics Control System Using a Parallel CLIPS Environment	PT	190-40	Active	208
Collision-Free Path Planning/Robotics Sotfware Test Bed Architecture	ER	190-34	Active	143
3-D Laser Vision Processor	EE	190-76	Active	49
Fault Tolerant Manipulator and Proof of Concept	ER	190-69	Active	123
Planetary Surface Systems HART Systems Engineering Studies	ER	190-154	Active	82
Robotic Gripper Controller Development	ER	190-120	Active, in use	75
Robotics Research Arm Advanced Controller Implementation	ER	190-124	Active	78
Robotic Vision/Tracking Sensors	ER	190-77	Active	125
Robot Path Planning Using Genetic Algorithms	PT	190-33	Active	239
Projects that continue at a low level of effort or are not active				
An Intelligent Mobile Research Robot	ER	190-116	discontinue	129
Control Architecture for Autonomous Robotic	ER	190-60	discontinued	151
Hardware-in-the-Loop Simulation	ER	190-122	low level	130
Multi-arm Robot Control Environment	ER	190-41	low level	85
Simulation of Robotics Space Operations	ER	190-36	in 190-41	144
Telerobotics Flight Experiment Definition	IC	190-27	inactive	176

Title	Division	Number	State	Page
Systems Autonomy Demonstration Project				
Cooperating Expert Systems	PT	190-11	Active	193
Projects that are not active				
Thermal Expert System (TEXSYS) for Control and Fault Diagnosis	EC	190-117	completed	44
Systems for Development of Intelligent Software				
AI Systems for Monitoring and Control	ER	190-58	Active	91
Automated Software Development Workstation (ASDW) Phase II	PT	190-101	Active	184
Automatic Scheduling Using A Genetic Algorithm Approach	PT	190-80	Active	223
C Language Integrated Production System (CLIPS)	PT	190-24	Active, in use	217
CLIPS Intelligent Tutor (CLIPSIT)	PT	190-23	Active	215
Cooperative Agreement with MCC	PT	190-108	Active	191
Development of an Ada-Based Version of ART	PT	190-12	Active	201
General Purpose Development Environment for ICAT Systems	PT	190-111	Active	195
Historical Software Development Cost Data Base	PT	190-104	Active	187
Software Life Cycle Support Environment (SLCSE) Beta Test	PT	190-102	Active	85
Spatiotemporal Neural Network Systems	PT	190-5	Active	244
The Parametric Avalanche Control Module Prototype Development	PT	190-28	Active	203

Title	Division	Number	State	Page
Projects that continue at a low level of effort or are not active				
Black Board Architecture Shell	ER	190-93	low level	160
Neural Network Simulation on Class VI Computers	PT	190-3	low level	238
Resource Planning and Management Expert System	PT	190-49	discontinued	243
Verification and Validation of Rule Based Systems	ER	190-138	in 190-84	139
Systems Using Intelligent Hardware				
Automatic Perception for NASA Mission Planning and Flight Control	PT	190-9	Active	213
Develop Neural Network Computer System	PT	190-7	Active	221
Systems Using Qualitative Modeling				
CONFIG: Qualitative and Discrete Event Fault Management Analysis Tools	ER	190-84	Active	105

* Described in more detail in Volume 1.

This page intentionally left blank.

PROJECTS REPORTED BY DA - ASSISTANT FOR ADVANCED PROJECTS

Category:	Projects
1.1 Knowledge	1

Level of Technological Readiness at the End of FY90	Projects
4 Critical Function or Characteristic Demonstrated	1

Number of Projects 1

Title	Number	Page
Operations Process Model	190-146	24

190-146

Title:
Operations Process Model

Description:
1. Research the NASA and non-NASA communities for cost-benefit models of the operations process, and select methodology appropriate to Mission Operations. 2. Develop prototype models of non-integrated MOD subprocesses; identify the type and format of data needed to initialize and validate the models. 3. Integrate individual prototypes of subprocess models into an interactive cost-benefit model.

Program: Mission Operations Efficiency Study
NASA Headquarters Program Code: IC
UPN/PWC: 906-21-01-15
Task no.: 6

Date: Apr 18, 1990

Point of Contact: T. W. Eggleston
Division: DA - Assistant for Advanced Projects

Telephone: 483-0520

State: Active

Categories Describing the Work of this Project:

1.1 Knowledge
2.1 Supporting software and hardware
1.4 Human-machine interface

1.4-7 Management of user interfaces
1.4-8 Maintenance of interfaces
1.4-9 Options for levels of automation

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Performing Organizations	Name of Contact	Telephone
McDonnell Douglas Space Systems Company	Jonathan Weiss	(713) 283-4347
ECON, Incorporated	Robert Phillips	(713) 554-7592

Current Status:
A candidate technology has been selected. Functional areas of the candidate operations process are being identified for prototype modeling. A prototype model of the STS Recon process was demonstrated at mid-term review.

Schedule:
Deliver prototype models of MOD subprocesses: Feb 90, Jun 90, Oct 90
Integrated model: Oct 91

PROJECTS REPORTED BY DE - SPACE STATION SYSTEMS DIVISION

Category:	Projects
1.1 Human-Machine Interface	1

Level of Technological Readiness at the End of FY90	Projects
6 Prototype or Engineering Model Tested in the Relevant Environment	1

Number of Projects 1

Title	Number	Page
On-Orbit Maintenance	190-145	26

190-145

Title:
On-Orbit Maintenance

Description:
Develop documentation and a proof-of-concept system to identify and define requirements for on-board maintenance of the Space Station. Use state-of-the-art equipment to develop a prototype system to demonstrate retrieval and presentation of maintenance information using mixed media.

Program: Space Station
NASA Headquarters Program Code:
Date: Apr 90

Point of Contact: Frank Janes
Division: DE - Space Station Systems
Section: Crew and Assembly Systems
Telephone: 283-5715

State: low level

Categories Describing the Work of this Project:

1.1 Knowledge
2.3 Knowledge based or expert systems

1.1-1 Acquisition of knowledge
1.1-9 Planning
2.3-2 Data base management
2.3-14 Servicing and repair

Funded: yes

Expected Level of Technology at the End of the Fiscal Year: 6 Prototype or engineering model tested in the relevant environment

Current Status:
Integration of CAD and expert systems has been delayed indefinitely. The project has been rehosted on a SUN workstation and is being used in MCC for in-flight maintenance for the Shuttle. The current direction is to develop a system for GFE for the Space Station Control Center. The system will be rehosted on Sun SPARC hardware.

Schedule:
Integration with the systems Operation Development Laboratory: Jan 87
Technical report completed: Sep 89 Integration with MCC: Sep 89

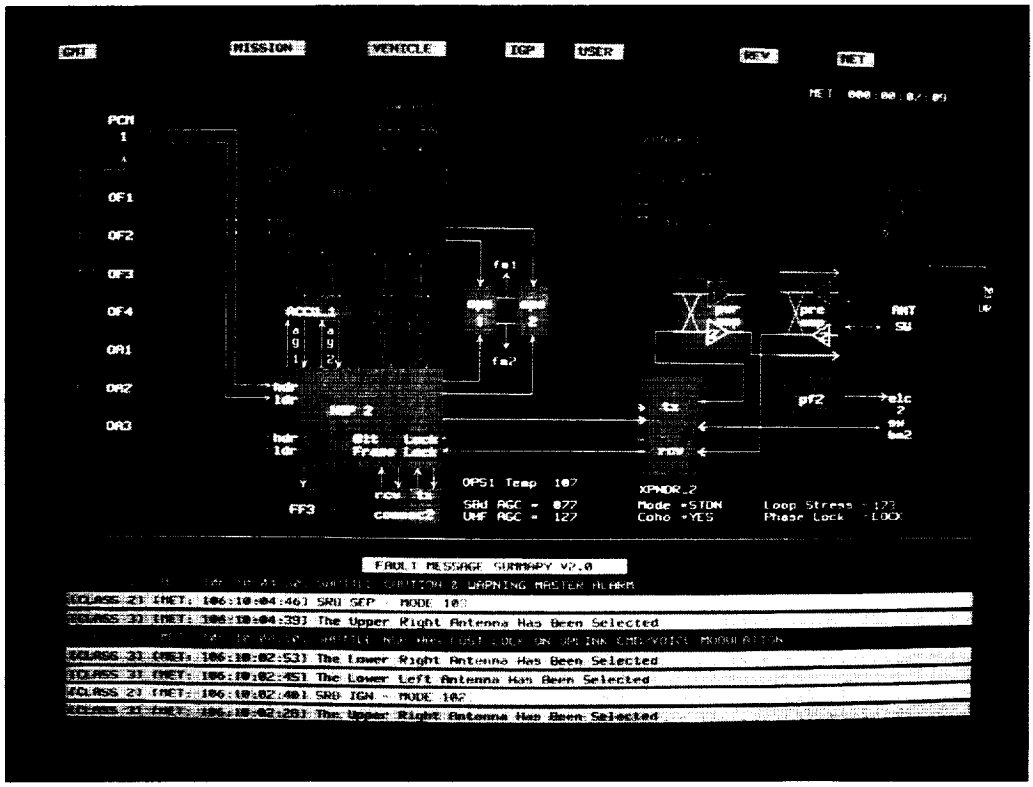
PROJECTS REPORTED BY DF - SYSTEMS DIVISION

Category:	Projects
2.3 Knowledge-Based or Expert Systems	1

Level of Technological Readiness at the End of FY90	Projects
8 Full Operational Capability (incorporated in production design)	1

Number of Projects 1

Title	Number	Page
Shuttle INCO Expert System/Real Time Data System	190-96	29



190-96 Shuttle INCO Expert System/Real Time Data System.

190-96

Title:
Shuttle INCO Expert System/Real Time Data System

Description:
Use distributed expert systems and automated tasks to provide information to flight controllers in real time. Advise flight controllers of faults in the telemetry. Operational systems monitor the main engine, communications, and mechanical and remote manipulator systems. Systems being developed include Guidance, Navigation, and Control, Life Support, Data Processing Systems, and Landing Sites.

Program: Shuttle Date: Jan 90
NASA Headquarters Program Code:
UPN/PWC: 549-03 488-05 906-21

Point of Contact: Troy A. Heindel Telephone: 483-2639
Division: DF - Systems
Branch: Communications and Data Systems
Section: Communications

State: in use

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems

2.3-9 Monitoring

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
8 Full operational capability (incorporated in production design)

Performing Organizations	Name of Contact	Telephone
The MITRE Corporation	Arthur Rasmussen	(713) 486-1984
DUAL Associates	Erick Kindred	(713) 486-1984

Current Status:
The system was used successfully during the flight of STS-26 in an advisory mode. It was used operationally during missions STS-29, STS-30, STS-28, STS-34, STS-33, and STS-32. An expert system for the main engine was developed and used operationally. A three–dimensional graphics program was developed and used operationally during STS-32.

Schedule:
Demonstration during simulations using real time data: Apr 88
Integration of the system into operations consoles: Apr 89
Use in a classified environment: Aug 89
Develop a remote manipulator monitoring system for use in STS-32: Dec 89
Develop a landing site expert system for use in STS-32: Jan 90
Develop a distributed expert system for bus loss: Jun 90

This page intentionally left blank.

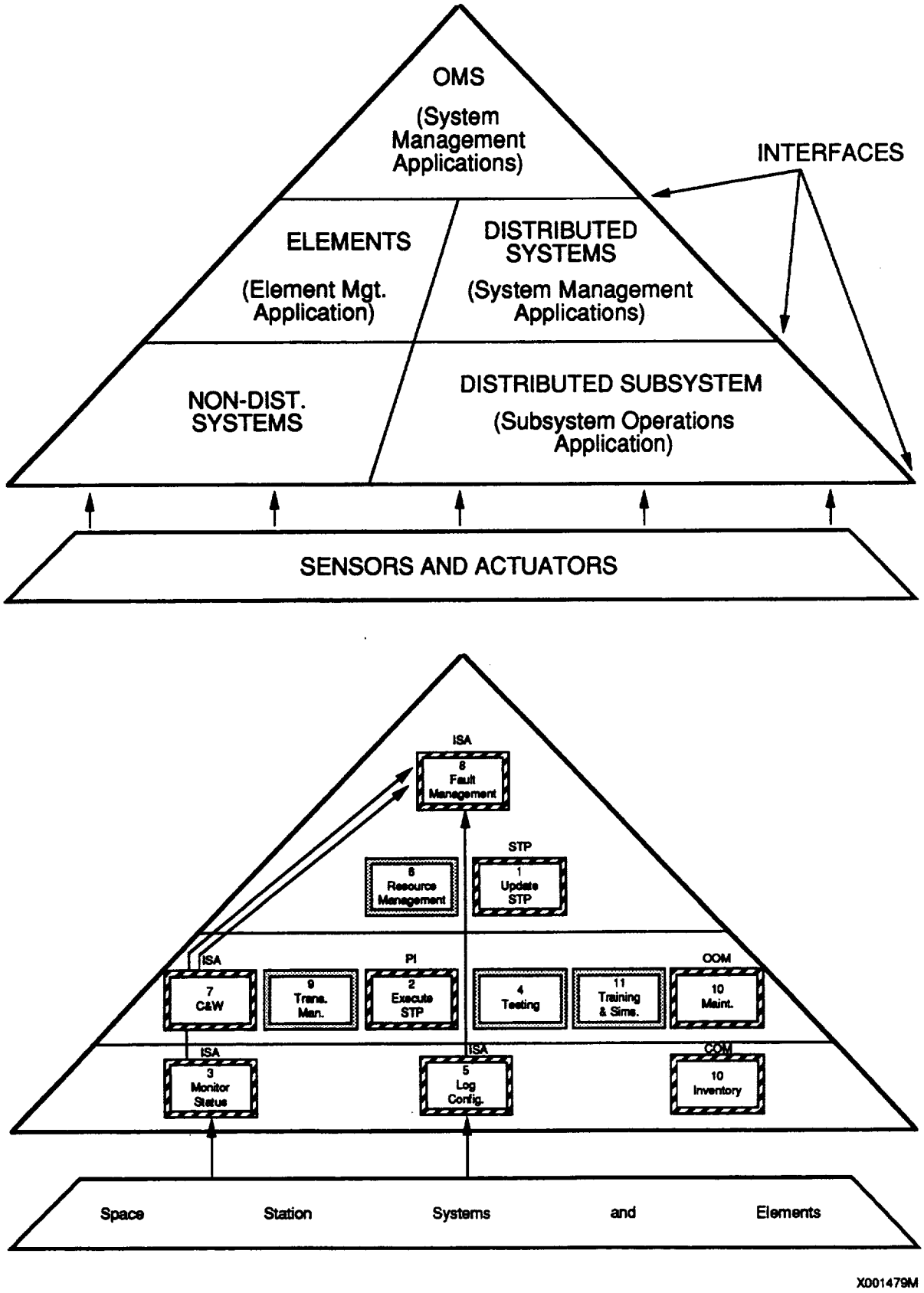
PROJECTS REPORTED BY DH - OPERATIONS DIVISION

Category:	Projects
2.1 Supporting Software and Hardware	1

Level of Technological Readiness at the End of FY90	Projects
6 Prototype or Engineering Model Tested in the Relevant Environment	1

Number of Projects 1

Title	Number	Page
System Management Applications	190-87	33



190-87 System management applications.

190-87

Title:
System Management Applications

Description:
Define interfaces between systems for integrated management of Space Station systems and individual core systems. Enhance the current prototype of system management and integrate it with the Data Management System Testbed.

Program: Space Station Date: Jan 90

Point of Contact: Richard D.Snyder Telephone: 483-4487
Division: DH - Operations
Branch: Flight Activity
Section: Orbit Procedures and FDF

State: Active

Categories Describing the Work of this Project:

2.1 Supporting software and hardware
2.3 Knowledge based or expert systems
1.4 Human-machine interface

2.1-2 Distributed systems
2.3-3 Distributed expert systems
2.3-7 Interacting expert systems
2.3-8 Management of faults
2.3-9 Monitoring
1.4-6 Interfaces to knowledge based or expert systems

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
The MITRE Corporation	Chris Marsh	(713) 333-0984

Current Status:
The prototype has been reimplimented using C and CLIPS, and runs in both PC and VAX environments. The prototype has communications with the Operations and Science Instrument Support (OASIS) software. The prototype has been updated to support the DMS testbed and activities related to the End-to-end Test Capabilities (ETC). This task is being continued as a project funded by MITRE.

Schedule: Document "Moving Expert Systems into Delivery Environments": April 1990 Test new implementation: September 1990

This page intentionally left blank.

PROJECTS REPORTED BY DJ - SPACE STATION FREEDOM GROUND SYSTEMS

Category:		Projects
2.2	System Design and Integration	1
2.3	Knowledge Based or Expert Systems	1

Level of Technological Readiness at the End of FY90	Projects
5 Component or Breadboard tested in the Relevant Environment	1
6 Prototype or Engineering Model Tested in the Relevant Environment	1

Number of Projects 2

Title	Number	Page
Automated Ground Systems Status/Control	190-20	37
Transition Flight Control Room Enhancement	190-21	39

This page intentionally left blank.

190-20

Title:
Automated Ground Systems Status/Control

Description:
Expert system technology and centralized control and collection of system status will be used to automate system control.

Program: NSTS
NASA Headquarters Program Code: M
UPN/PWC: 906-21-03

Date: July 89

Point of Contact: Alan Brewer
Division: DJ - Space Station Freedom Ground Systems
Branch: ADPE and Support Systems Office

Telephone: 483-7042

State: Active

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems
2.1 Supporting software and hardware

2.3-1 Control
2.3-9 Monitoring
2.1-1 Accommodation for automation & robotics in design
2.1-2 Distributed systems
2.1-7 Uninterruptable systems

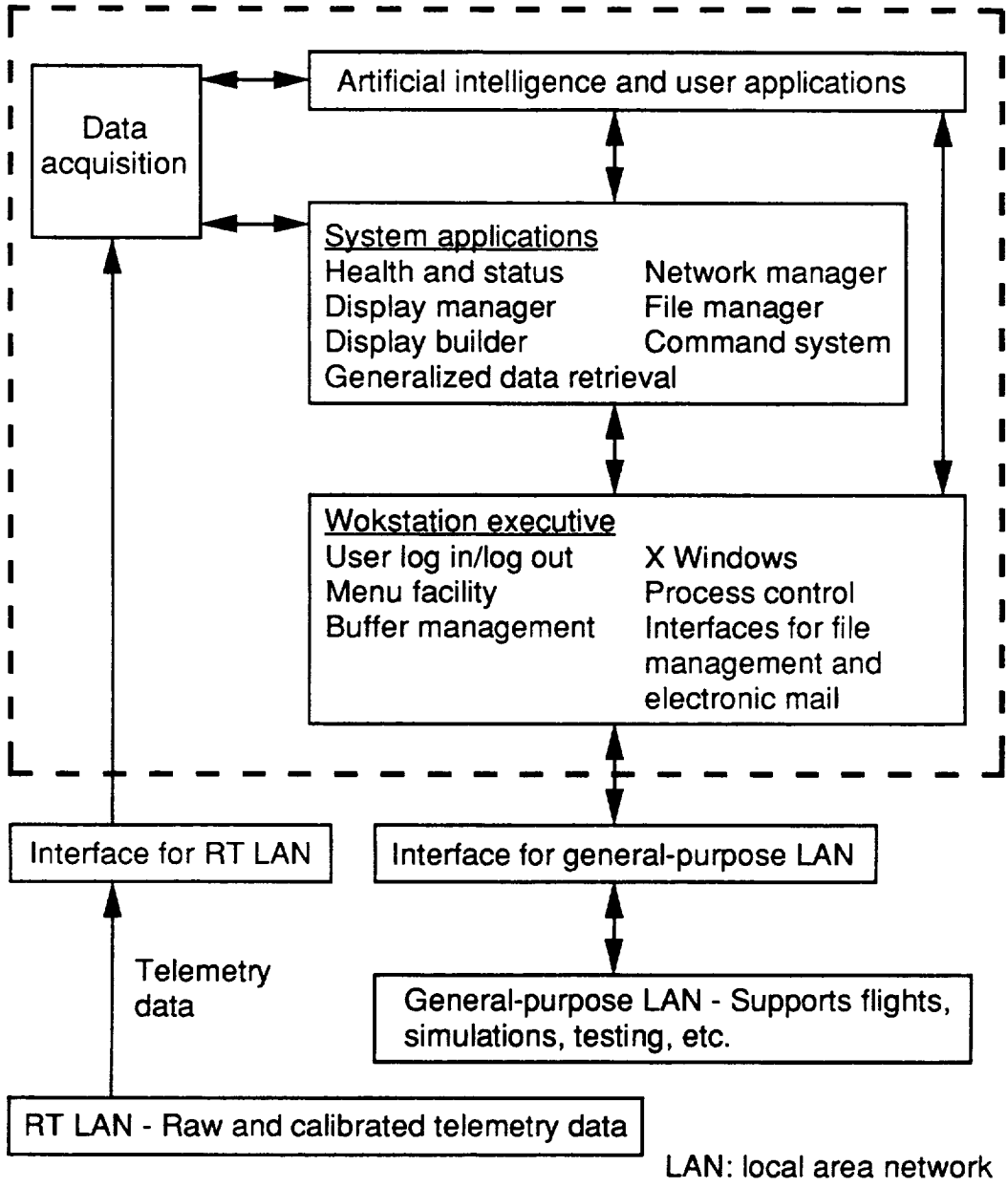
Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
Ford Aerospace Corp.	George Scheuch	(713) 483-7533
Southwest Research Institute	David Kreidler	(512) 522-3677

Current Status:
Ongoing.

Schedule:
FY89: System definition
FY90: Complete modifications
FY91: Completion of the expert system
FY92: Full implementation in the MCC



190-21 Transition Flight Control Room enhancement.

190-21

Title:
Transition Flight Control Room Enhancement

Description:
Augment the capabilities of the Transition Flight Control Room to provide an environment that is independent of hardware in which advanced automation software for the control center for Space Station Freedom can be developed and integrated.

Program: Space Station Freedom
NASA Headquarters Program Code: S
UPN/PWC: 488-50

Date: June 89

Point of Contact: Curtis Welborn
Division: DJ - Space Station Freedom Ground Systems
Branch: Control Center Systems
Section: Flight and Ground Support Systems

Telephone: 483-7065

State: Active

Categories Describing the Work of this Project:

2.2 System design and integration
2.1 Supporting software and hardware

2.2-7 Environments for automation
2.2-3 Aids for programming
2.1-1 Accommodation for automation & robotics in design
2.1-2 Distributed systems
2.1-3 Fault-tolerant architecture
2.1-6 Specialized architecture for artificial intelligence

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
5 Component or breadboard tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
LINCOM	Dr. Yashvent Jani	(713) 333-1625
LINCOM	Wayne Parrott	(713) 483-3735
McDonnell Douglas Space Systems Company	Charles Robertson	(713) 483-3735

Current Status:
Ongoing.

Schedule:
Develop criteria for selection: FY89
Evaluate the selected environment: FY90
Document architectural recommendations: FY91

This page intentionally left blank.

PROJECTS REPORTED BY EC - CREW AND THERMAL SYSTEMS DIVISION

Category:		Projects
1.3	Actuation and Manipulation	1
2.3	Knowledge-Based or Expert Systems	1
2.4	Robotic and Telerobotic Systems	1

Level of Technological Readiness at the End of FY90	Projects
3 Conceptual Design Tested	2
6 Prototype or Engineering Model Tested in the Relevant Environment	1

Number of Projects 3

Title	Number	Page
FTS/WP-2 Accommodations Issues Task	190-42	42
Space Station Assembly Task Identification and Assessment	190-43	43
Thermal Expert System (TEXSYS) for Control and Fault Diagnosis	190-117	44

190-42

Title:
FTS/WP-2 Accommodations Issues Task

Description:
Available commercial manipulator systems and WP-2 hardware mockups will be utilized to perform tests to assess compatibility of FTS with Space Station assembly tasks. EVA backup capability will be maintained for all tasks. Products will be concepts for an FTS tool set, final test reports for task evaluations, and inputs to FTS and WP-2 hardware designs.

Program: Space Station/FTS Project
NASA Headquarters Program Code:
UPN/PWC: 486-81-08

Date: January 1990

Point of Contact: C. E. Whitsett
Division: EC - Crew and Thermal Systems
Branch: Special Projects
Section:

Telephone: 483-9111

State: Active

Categories Describing the Work of this Project:

1.3 Actuation and manipulation
2.4 Robotic and telerobotic systems

1.3-7 End effectors
1.3-8 Manipulators
2.4-1 Assembly
2.4-4 Construction
2.4-5 Handling of parts
2.4-6 Servicing and repair

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
3 Conceptual design tested

Performing Organizations	Name of Contact	Telephone
McDonnell Douglas Space Systems Company	L. V. Ramon	(713) 280-1500
Ocean Systems Engineering	D. Vervaet	(713) 492-2800

Current Status:
This is a new task.

Schedule:

190-43

Title:
Space Station Assembly Task Identification and Assessment

Description:
Evaluate utilization of FTS for assembly and maintenance of the Space Station. Develop a plan to evaluate and verify capabilities of the FTS to perform selected tasks. Support WP-2 hardware design, development, and integration with the FTS project at GSFC. Products include studies of FTS utilization, concepts for interfaces and tools common to EVA and FTS, test plans for task evaluations, and hardware mockups.

Program: Space Station/FTS Project
NASA Headquarters Program Code:
UPN/PWC: 486-81-02

Date: Dec 89

Point of Contact: C. E. Whitsett
Division: EC - Crew and Thermal Systems
Branch: Special Projects
Section:

Telephone: 483-9111

State: Active

Categories Describing the Work of this Project:

2.4 Robotic and telerobotic systems
1.3 Actuation and manipulation

2.4-1 Assembly
2.4-2 Automatic inspection
2.4-3 Computer vision systems
2.4-6 Servicing and repair
1.3-7 End effectors
1.3-8 Manipulators

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
3 Conceptual design tested

Performing Organizations	Name of Contact	Telephone
McDonnell Douglas Space Systems Company	L. V. Ramon	(713) 280-1500

Current Status:
The tasks described are being performed. Documentation of work performed to date is available through the Crew and Thermal Systems Division.

Schedule:
Contact the representative of the Crew and Thermal Systems Division for a detailed schedule.

190-117

Title:
Thermal Expert System (TEXSYS) for Control and Fault Diagnosis

Description:
Develop an expert system to control a thermal system representative of those on the Space Station. The controller will be demonstrated using the Thermal Test Bed at JSC.

Program: OAST System Autonomy Demonstration Date: Mar 90
NASA Headquarters Program Code:
UPN/PWC: 549-03-21
Task no.: 6

Point of Contact: Jeff Dominick Telephone: 483-9132
Division: EC - Crew and Thermal Systems
Branch: Thermal Systems

State: completed

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems
1.3 Actuation and manipulation
1.4 Human-machine interface
1.1 Knowledge

2.3-1 Control
2.3-9 Monitoring
1.3-1 Actuation in expert systems
1.4-6 Interfaces to knowledge based or expert systems
1.1-12 Representation and reasoning

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Current Status:
Integration and preliminary testing are almost complete. Interactive testing on a live test article will begin July 10, 1989. It is expected that the final demonstration will take place in August 1989.

Schedule:
Requirements defined: Jul 88
Interfaces defined: Oct 88
Verification testing completed: Apr 89
Demonstration test: Aug 89
The project will be completed in FY89.

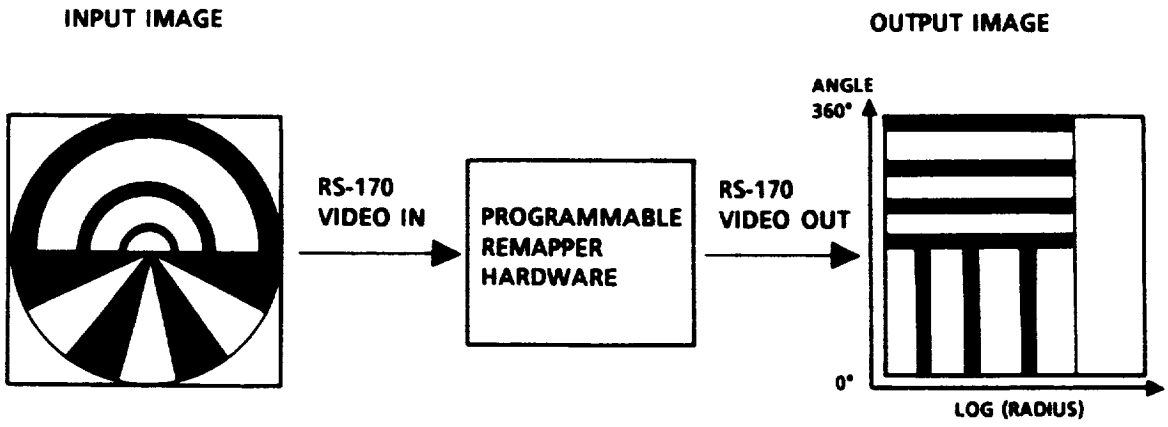
PROJECTS REPORTED BY EE - TRACKING AND COMMUNICATIONS DIVISION

Category:	Projects
1.1 Knowledge	1
1.2 Sensing	3
1.4 Human-Machine Interface	1
2.1 Supporting Software and Hardware	1
2.3 Knowledge-Based or Expert Systems	3

Level of Technological Readiness at the End of FY90	Projects
4 Critical Function or Characteristic Demonstrated	5
5 Component or Breadboard Tested in the Relevant Environment	1
6 Prototype or Engineering Model Tested in the Relevant Environment	1
Technology level not given	2

Number of Projects 9

Title	Number	Page
3-D Laser Vision Processor	190-76	49
Automated Antenna Management	190-152	51
Automated Fault Isolation by Bit Strings	190-151	50
Automated Resource Manager	190-153	52
Control System Use of Optical Correlator Vision	190-172	55
Hybrid Vision Laboratory	190-119	56
Image Remapping	190-73	47
Programmable 3D Range/Doppler Imagine Ladar	190-75	48
Remapping for Low Vision	190-74	57



Log polar transformation.

190-73 Image remapping.

190-73

Title:
Image Remapping

Description:
Develop algorithms and mappings for the Programmable Remapper, an image processor what will operate at video rates to perform coordinate transformations on an input image. Applications of the remappings include the space vision problem (including rotation and invariance of scale), rendezvous, docking, station keeping, and image flow.

Program: Small Business Innovative Research Date: Jan 90

Point of Contact: Richard Juday Telephone: 483-1486
Division: EE - Tracking and Communications
Branch: Tracking Techniques
Section: Tracking Systems

State: Active

Categories Describing the Work of this Project:

1.2 Sensing
2.4 Robotic and telerobotic systems

1.2-14 Visual and optical
2.4-3 Computer vision systems
1.2-2 Coding of sensor informatio

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Performing Organizations	Name of Contact	Telephone
Transitions Research Corporation	Carl Weiman	(203) 798-8988

Current Status:
Carl Weiman, under SBIR contract, is developing a prototype hardware system to implement the visual system with an exponential sensor array that was researched in Phase I; algorithms for task applications will be included.

Schedule:
Delivery of hardware: March 1990

190-75

Title:
Programmable 3D Range/Doppler Imaging Ladar

Description:
Develop an imaging coherent infrared carbon dioxide ladar with multifunction range, velocity, and intensity. It will provide motion detection and tracking over a hemisphere and fine resolution for 3D image-based object recognition. It will be safe over a large area in a dynamic environment and provide accurate data needed for complex tasks such as robotic vision, rendezvous, and docking for space vehicles.

Program: SBIR
NASA Headquarters Program Code: CR
UPN/PWC: 324-02-EA-12

Date: January 10, 1990

Point of Contact: Joseph L. Prather
Division: EE - Tracking and Communications
Branch: Tracking Techniques

Telephone: 483-1483

State:

Categories Describing the Work of this Project:

1.2 Sensing
1.2-11 Range and rate
1.2-14 Visual and optical

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
Autonomous Technologies Corporation	Randy W. Frey	(407) 282-1262

Current Status:
Midway through Phase II.

Schedule:
Contract award/ATP: July 1989
Delivery of the engineering model: August 1990

190-76

Title:
3-D Laser Vision Processor

Description:
Develop and implement algorithms to manipulate 3D range-reflectance maps to provide robotic systems with a capability for autonomous recognition and tracking of targets. The first application is the EVA Retriever. Input will be Odetics 3D mapper data; output will be orientation of identified targets and locations of obstacles. Partial capability for recognition of occlusion is expected.

Program: Advanced Programs
NASA Headquarters Program Code: RC
UPN/PWC: 549-01-31-01

Date: Jan 8, 1990

Point of Contact: Kent Dekome
Division: EE - Tracking and Communications
Branch: Tracking Techniques
Section: Microwave and Laser

Telephone: 483-1453

State: Active

Categories Describing the Work of this Project:

1.1 Knowledge
2.4 Robotic and telerobotic systems
2.1 Supporting software and hardware

1.1-11 Recognition of objects
2.4-3 Computer vision systems
2.1-1 Accommodation for automation & robotics in design

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
5 Component or breadboard tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
Loral Defense Systems	Don Rohrbacher	(216) 796-1760

Current Status:
The contract was awarded and effective July 1, 1989. The contract period is currently about one-half finished.

Schedule:
July 1, 1989: Contract start date.
June 1990: Acceptance testing.
July 1990: Final report and integration into the EVAR.
August 1990: Active use and modifications.

190-151

Title:
Automated Fault Isolation by Bit Strings

Description:
The fault network from the Harris fault management expert system was compiled into a set of bit strings that encapsulate the essential information required for fault isolation. The fault net represents the cause-effect relationships between problems and their immediate effects. The current executable FIBS program needs less than 140 K bytes for 844 symptoms and 224 problems; the bit strings use 31 Kbytes.

Program: Advanced Programs
NASA Headquarters Program Code:
UPN/PWC: 472-43-EA-73
Task no.: 3

Date: May 90

Point of Contact: Oron L. Schmidt
Division: EE - Tracking and Communications
Branch: Communications Performance and Integration
Section: Systems Techniques

Telephone: 483-0133

State: low level

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems

2.3-3 Distributed expert systems
2.3-7 Interacting expert systems
2.3-8 Management of faults
2.3-9 Monitoring

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Current Status:
The original Fault Isolation by Bit Strings (FIBS) was generated using C. It is being rewritten in Ada and is undergoing performance optimization.

Schedule:
Prototype implemented in C: June 89
Rewritten in Ada: January 90
Demonstration: August 90

190-152

Title:
Automated Antenna Management

Description:
The Space Station Freedom Communication and Tracking (C&T) antennas will be managed by the Control and Monitoring Subsystem (CMS). Software using FIBS (Fault Isolation by Bit Strings) will be developed for the Control and Monitoring Subsystem.

Program: Advanced Programs Date: May 90
NASA Headquarters Program Code:
UPN/PWC: 472-43-EA-73
Task no.: 2

Point of Contact: Oron L. Schmidt Telephone: 483-0133
Division: EE - Tracking and Communications
Branch: Communications Performance and Integration
Section: Systems Techniques

State: low level

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems

2.3-1 Control
2.3-3 Distributed expert systems
2.3-7 Interacting expert systems
2.3-8 Management of faults
2.3-9 Monitoring

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Current Status:
The original Fault Isolation by Bit Strings (FIBS) was generated using C. It is being rewritten in Ada and is undergoing performance optimization.

Schedule:
Prototype implemented in C: June 89
Rewritten in Ada: January 90
Demonstration: August 90

190-153

Title:
Automated Resource Manager

Description:
The Space Station Freedom Communications and Tracking (C&T) antennas will be managed by the Control and Monitoring Subsystem (CMS). Prototype software will be developed for automated management of resources of the C&T subsystems.

Program: Advanced Programs Date: May 90
NASA Headquarters Program Code:
UPN/PWC: 472-43-EA-73
Task no.: 3

Point of Contact: Oron L. Schmidt Telephone: 483-0133
Division: EE - Tracking and Communications
Branch: Communications Performance and Integration
Section: Systems Techniques

State: low level

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems

2.3-1 Control
2.3-3 Distributed expert systems
2.3-7 Interacting expert systems
2.3-9 Monitoring

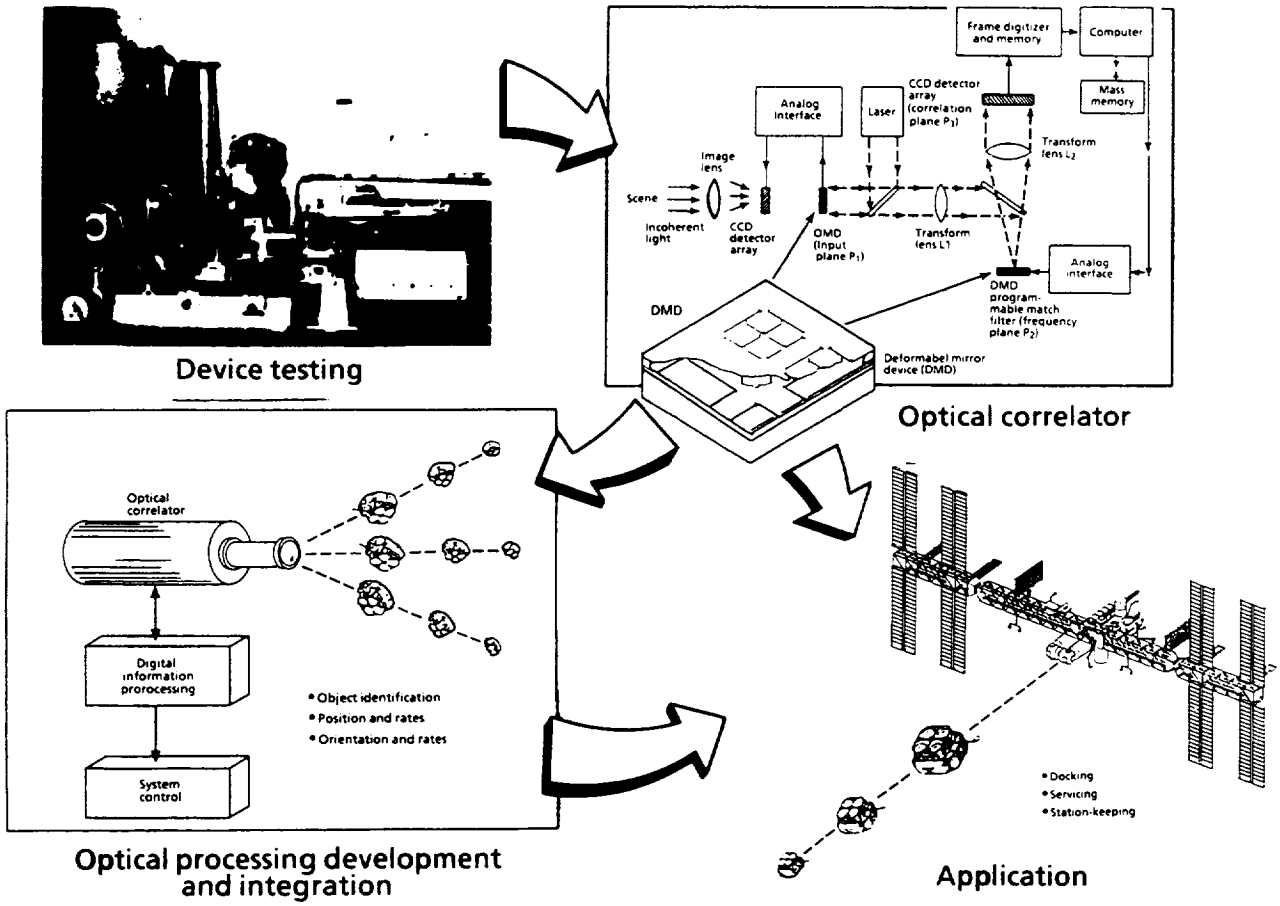
Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Current Status:
The first prototype C&T resource manager has been developed for the Data Management System (DMS) test bed Scenario 3B tests. This software will be modified to accept high level commands from the Operation Management Application (OMA) and execute the correct procedures to configure C&T subsystem strings.

Schedule:
Scenario 3B resource manager complete and tested: April 90
Automated resource manager complete: November 90
Demonstration of the system: January 91

This page intentionally left blank.



190-72 Control system use of optical correlator vision.

190-72

Title:
Control System Use of Optical Correlator Vision

Description:
Develop systems, for use in robotics and proximity operations, that use optical correlators to identify objects and estimate their position and attitude. The end product will be a system that can be used in the Space Station and in other applications.

Program: Advanced Programs
NASA Headquarters Program Code:
UPN/PWC: 141

Date: Jan 90

Point of Contact: Richard Juday
Division: EE - Tracking and Communications
Branch: Tracking Techniques
Section: Tracking Systems

Telephone: 483-1486

State: Active

Categories Describing the Work of this Project:

1.2 Sensing
2.3 Knowledge based or expert systems
1.3 Actuation and manipulation
2.4 Robotic and telerobotic systems

1.2-2 Coding of sensor information
1.2-14 Visual and optical
2.3-1 Control
1.3-5 Control technology
2.4-3 Computer vision systems

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Current Status:
The hardware from Texas Instruments has been delivered. Testing at JSC is continuing with current devices. Hardware and software are being upgraded. The theory of filtering with limited-range phase-mostly spatial light modulators is being developed, published, and put into practice.

Schedule:
Laboratory correlator system completed: May 1988
Implementation of synthetic estimation filter: Dec 1988
Deformable mirror devices of image quality developed: March 1990

190-119

Title:
Hybrid Vision Laboratory

Description:
An object rotator being constructed in the Hybrid Vision Laboratory will run under control of correlator vision and be capable of working with projects that include imaging of synthetic vision. Facilities in the laboratory include an air suspension optics table, a computer controlled two-axis rotator, hardware for an optical correlator, a TI computer and Mercury array processor for processing digital imagery.

Program: Date: Feb 90

Point of Contact: Richard Juday Telephone: 483-1486
Division: EE - Tracking and Communications
Branch: Tracking Techniques
Section: Tracking Systems

State: inactive

Categories Describing the Work of this Project:

2.1 Supporting software and hardware

2.1-1 Accommodation for automation & robotics in design
2.1-5 Programming languages

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
Level not given

Current Status:
The correlator system is functioning. Multi-tasking control architecture needs to be acquired and developed into a system.

Schedule:
Delivery of the video rate image transformer (the Programmable Remapper): Mar 88
Implementation of joint transform techniques: Aug 88

190-74

Title:
Remapping for Low Vision

Description:
Use the Programmable Remapper in the solution of problems of impaired vision where either the central or peripheral portion of the field of vision has become non-functional: A remapped video image will be placed on the still viable portions of the retina. The system will be tested at the Lighthouse of Houston, JSC, and the University of Houston.

Program: NASA Technology Utilization Date: Jan 90

Point of Contact: Richard Juday Telephone: 483-1486
Division: EE - Tracking and Communications
Branch: Tracking Techniques
Section: Tracking Systems

State: Active

Categories Describing the Work of this Project:

1.4 Human-machine interface
2.4 Robotic and telerobotic systems

1.4-2 Displays
2.4-3 Computer vision systems

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
Level not given

Current Status:
Dr. David Loshin of the College of Optometry at the University of Houston and Dr. Richard Juday of JSC have worked through static images through remappings. Preliminary results were presented at meetings of the American Academy of Optometry (December 1986) and the Association for Research in Vision and Ophthalmology (May 1987). A journal article has been published. Dr. Loshin did a two-semester sabbatical at JSC.

Schedule:
Remapper hardware upgrades: March 1990
Helmet display: March 1990
Clinical studies begin: May 1990

This page intentionally left blank.

PROJECTS REPORTED BY EK - FLIGHT DATA SYSTEMS DIVISION

Category:		Projects
2.1	Supporting Software and Hardware	2
2.2	System Design and Integration	6
2.3	Knowledge-Based or Expert Systems	2

Level of Technological Readiness at the End of FY90		Projects
3	Conceptual Design Tested	1
4	Critical Function or Characteristic Demonstrated	2
5	Component or Breadboard Tested in the Relevant Environment	1
6	Prototype or Engineering Model Tested in the Relevant Environment	5
8	Full Operational Capability (incorporated in production design)	1

Number of projects 10

Title	Number	Page
ACES – Analysis Criteria Evaluation System	190-97	63
Automation Test Bed	190-126	66
DASHES – Dump Analysis for Simulator/Hardware Expert System	190-98	64
LATEST – Launch Countdown Anomaly using Expert Systems Technology	190-99	65
QUEST – Quality Expert System Tool	190-100	61
RDIA – Requirements Decision Impact Assessment	190-150	71
Real-Time Garbage Collection	190-130	67
SHADES – Shuttle AP-101 Diagnostic Expert System	190-148	69
SILES – Shuttle I-Load Expert System	190-147	68
SPLINTER – SpaceLab Integration	190-149	70

This page intentionally left blank.

190-100

Title:
QUEST – Quality Expert System Tool

Description:
Develop an expert system for automatic analysis of the quality of flight software for a given release.

Program: OBS/Shuttle

Date: Jan 90

Point of Contact: William Pruett

Telephone: 483-5298

Division: EK - Flight Data Systems
Branch: Shuttle Software
Section: Software Integration & Maintenance

State: low level in use

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems

2.3-11 Programming support

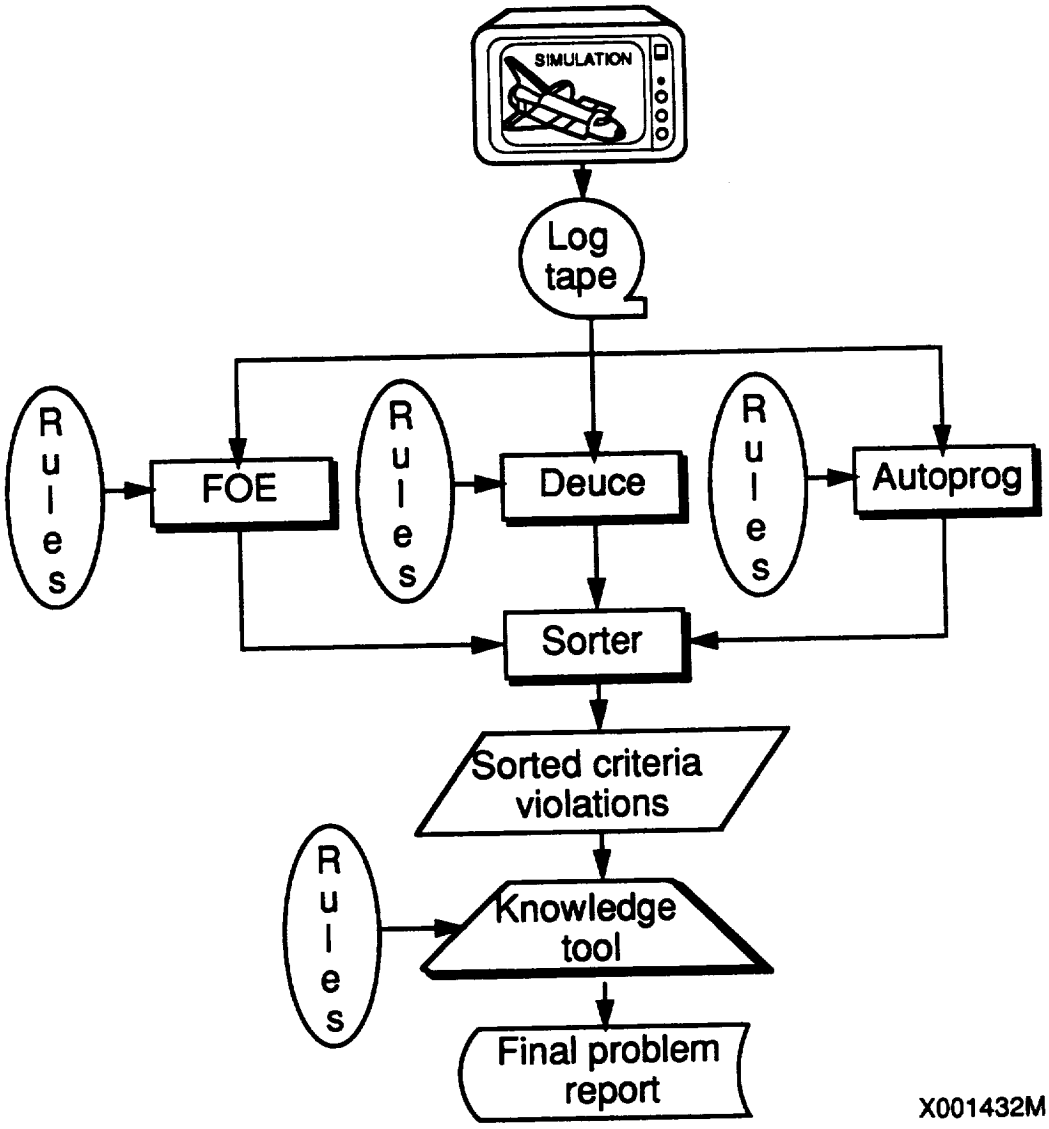
Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
8 Full operational capability (incorporated in production design)

Performing Organizations	Name of Contact	Telephone
IBM	R. K. Avery	(713) 282-8763

Current Status:
Documentation is in progress

Schedule:
Complete documentation to place the tool under tools configuration control: Sep 90



190-97 ACES - Analysis criteria evaluation system.

190-97

Title:
ACES - Analysis Criteria Evaluation System

Description:
Develop an expert system to assist performance analysts in the analysis of data from simulation runs made to evaluate flight software.

Program: OBS/Shuttle Date: Jan 90

Point of Contact: William Pruett Telephone: 483-5298
Division: EK - Flight Data Systems
Branch: Shuttle Software
Section: Software Integration & Maintenance

State: Active

Categories Describing the Work of this Project:

2.2 System design and integration
2.3 Knowledge based or expert systems

2.2-5 Automatic checkout and test
2.3-4 Engineering support
2.3-11 Programming support

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
IBM	R. K. Avery	(713) 282-8763

Current Status:
KT (Knowledge Tool) is being used for the production system. The knowledge base is about 90% complete. The tool and knowledge base for DEU (Display Electronic Unit) and on-line analysis (DEUCE and FOE) plot analysis (AUTO PROG) have been baselined. The expert system for nominal deorbit is in production.

Schedule:
Combine ascent KBs; combine entry KBs: December 1990
Baseline AUTOPROG KBs: December 1990

190-98

Title:
DASHES – Dump Analysis for Simulator/Hardware Expert System

Description:
Develop an expert system to aid the people who use and maintain the Onboard Shuttle Simulator by diagnosing problems in hardware, system loading, and procedures.

Program: OBS/Shuttle Date: Jan 90

Point of Contact: William Pruett Telephone: 483-5298
Division: EK - Flight Data Systems
Branch: Shuttle Software
Section: Software Integration & Maintenance

State: Active

Categories Describing the Work of this Project:

2.2 System design and integration
2.3 Knowledge based or expert systems

2.2-4 Automated software development
2.3-11 Programming support

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
IBM	R. K. Avery	(713) 282-8763

Current Status:
The knowledge base has been converted to Knowledge Tool and is being augmented. A dump data extractor has been developed.

Schedule:
Complete dump extractor: Jul 89
Augment the knowledge base: Dec 90
Complete preliminary release acceptance testing by the user: Aug 90

190-99

Title:
LATEST – Launch Countdown Anomaly using Expert Systems Technology

Description:
Develop an expert system to diagnose causes of aborts and holds of launches.

Program: OBS/Shuttle Date: Jan 90

Point of Contact: William Pruett Telephone: 483-5298
Division: EK - Flight Data Systems
Branch: Shuttle Software
Section: Software Integration & Maintenance

State: Active

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems

2.3-9 Monitoring
2.3-11 Programming support

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
IBM	R. K. Avery	(713) 282-8763

Current Status:
The knowledge base for the main engine of the Shuttle is complete. This expert system has been made into a tool for T&O. Connection to the telemetry stream is being investigated.

Schedule:
Connection to the real telemetry stream: TBD

190-126

Title:
Automation Test Bed

Description:
Develop an Automation Test Bed to be used for assessing the design, and testing and verifying the hardware and software, for expert systems for avionics for the Space Station, and for testing and verifying their interaction with the Data Management System Test Bed. Develop methods for verifying expert systems and evaluating their performance in the distributed environment of the Data Management System.

Program: Space Station Date: Feb 90

Point of Contact: Robert G. Musgrove Telephone: 483-8356
Division: EK - Flight Data Systems
Branch: Data Systems

State: Inactive

Categories Describing the Work of this Project:

2.1 Supporting software and hardware

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Current Status:
The project was not funded, and is inactive.

Schedule:
FY86-87: Construct the automation test bed and provide the needed connections.
FY88: Integrate the distributed expert systems into the automation test bed. Develop scenarios for testing the Orbital Maneuvering system and the Data Management System. Integrate symbolics processors that are candidates for use in the flight system into the Automation Test Bed.

190-130

Title:
Real-Time Garbage Collection

Description:
Develop an improved method for collection in real time of garbage generated during list processing.

Program: Space Station

Date: Feb 90

Point of Contact: R. Shuler
Telephone: 483-5258
Division: EK - Flight Data Systems
Branch: Systems Development
Section: Systems Integration

State: inactive

Categories Describing the Work of this Project:

2.1 Supporting software and hardware

2.1-6 Specialized architecture for artificial intelligence
2.1-4 Management of resources

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
3 Conceptual design tested

Current Status:
The basic theoretical work has been completed and published. A patent has been applied for. It is expected that a patent will be issued in March 1990.

Schedule:
Basic theoretical work has been completed.
A patent application has been filed.

190-147

Title:
SILES – Shuttle I-Load Expert System

Description:
Develop an expert system to determine initial values for variables to be used by the flight software, automating a process that is cumbersome and prone to error.

Program: OBS/Shuttle Date: May 90

Point of Contact: William Pruett Telephone: 483-5298
Division: EK - Flight Data Systems
Branch: Shuttle Software
Section: Software Integration & Maintenance

State: inactive

Categories Describing the Work of this Project:

2.2 System design and integration
2.3 Knowledge based or expert systems

2.2-10 Validation and verification
2.3-4 Engineering support
2.3-11 Programming support

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Current Status:
Inactive

Schedule:

190-148

Title:
SHADES – Shuttle AP-101 Diagnostic Expert System

Description:
Develop an expert system to diagnose failures in computers aboard the Shuttle.

Program: OBS/Shuttle

Date: May 90

Point of Contact: William Pruett

Telephone: 483-5298

Division: EK - Flight Data Systems
Branch: Shuttle Software
Section: Software Integration & Maintenance

State: inactive

Categories Describing the Work of this Project:

2.2 System design and integration
2.3 Knowledge based or expert systems

2.2-5 Automatic checkout and test
2.3-4 Engineering support

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Current Status:
The knowledge base for diagnosing hardware errors in AP101B is incomplete.

Schedule:

190-149

Title:
SPLINTER – SpaceLab Integration

Description:
Develop an expert system to help the software systems engineer in the interpretation of I/O between the Space Shuttle General Purpose Computers and the spacelab computers within the spacelab module.

Program: OBS/Shuttle

Date: May 89

Point of Contact: William Pruett

Telephone: 483-5298

Division: EK - Flight Data Systems
Branch: Shuttle Software
Section: Software Integration & Maintenance

State: discontinued

Categories Describing the Work of this Project:

2.2 System design and integration
2.3 Knowledge based or expert systems

2.2-5 Automatic checkout and test
2.3-11 Programming support

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Current Status:
The prototype is in use.

Schedule:

190-150

Title:
RDIA – Requirements Decision Impact Assessment

Description:
Develop an expert system for assessing the impacts that changes in requirements will have on an existing set of requirements based on changes in requirements. Knowledge bases of requirements for the Software Production Facility (SPF) fall into four sets: SPF configuration management, SPF build, SPF test, and SPF system management.

Program: OBS/Shuttle

Date: May 90

Point of Contact: William Pruett

Telephone: 483-5298
Division: EK - Flight Data Systems
Branch: Shuttle Software
Section: Software Integration & Maintenance

State: discontinued in use

Categories Describing the Work of this Project:

2.2 System design and integration
2.3 Knowledge based or expert systems

2.2-1 Aids for documentation
2.2-3 Aids for programming
2.3-11 Programming support

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
5 Component or breadboard tested in the relevant environment

Current Status:
The configuration management knowledge base is in production use by writers of requirements. Knowledge bases for build, test, and system management have not been developed.

Schedule:

This page intentionally left blank.

PROJECTS REPORTED BY ER - AUTOMATION AND ROBOTICS DIVISION

Category:		Projects
1.1	Knowledge	5
1.2	Sensing	2
1.3	Actuation and Manipulation	14
1.4	Human-Machine Interface	7
2.1	Supporting Software and Hardware	6
2.2	System Design and Integration	6
2.3	Knowledge-Based or Expert Systems	11
2.4	Robotic and Telerobotic Systems	10

Level of Technological Readiness at the End of FY90		Projects
1	Basic Principle Observed or Reported	6
2	Conceptual Design Formulated	7
3	Conceptual Design Tested	7
4	Critical Function or Characteristic Demonstrated	19
5	Component or Breadboard Tested in the Relevant Environment	6
6	Prototype or Engineering Model Tested in the Relevant Environment	8
8	Full Operational Capability (incorporated in production design)	4
Technology level not given		4

Number of Projects 61

Title	Number	Page
AI Systems for Monitoring and Control	190-58	91
Active Thermal Control System – Simulation and Fault Management	190-92	115
Advanced Automation Methodology Project	190-88	109
Advanced Automation Network Monitoring System	190-89	111
Advanced Development for Space Robotics	190-68	101
Advanced Force/Torque Control Study for the RMS System	190-123	77
Advanced Graphics Laboratory Systems Development	190-132	133
Algorithm for Using Multiple Manipulator Arms to Control a Payload	190-67	157
An Intelligent Mobile Research Robot	190-116	129
Architectures for Semi-Autonomous Planning	190-57	89
Automated Robotic Assembly of Space Station	190-144	81
Autonomous Lander for Planetary Exploration	190-64	95
Black Board Architecture Shell	190-93	160
CONFIG: Qualitative and Discrete Event Fault Management Analysis Tools	190-84	105
Collision-Free Path Planning/Robotics Software Test Bed Architecture	190-34	143
Connected Autonomous Neutral Sight-Arm System (CANSAS)	190-95	162
Control Architecture for Autonomous Robotics	190-60	151
Definition of Advanced Automation Testbed Requirements	190-52	147
Design Knowledge Capture	190-53	87
Diagnostic Reasoner/Recovery Expert	190-90	113

Title	Number	Page
Dual Actuator Robotic Joint Mechanism	190-121	76
Dynamic Modeling of 6+ DOF Robotic Manipulator Systems	190-156	84
EVA Retriever Central Software	190-56	149
EVA Retriever Ground Demonstration	190-66	99
EVA Retriever Test Bed	190-47	121
EVA Retriever Vision/Tracking System	190-78	127
Electrolysis Fault Diagnosis Expert System	190-94	161
Enhancement of Simulation/Animation Graphics System	190-138	134
Expert Systems for Execution of Crew Procedures	190-70	103
Fault Tolerant Manipulator and Proof of Concept	190-69	123
Free-Flyer/Fault Detection and Correction System	190-46	119
Free-Flyer/Robotic Arm Positioning Techniques	190-45	117
Functional Area Manager for Design Knowledge Capture	190-22	142
Functional Area Manager for Work Package 2 Advanced Automation	190-91	114
Hardware-in-the-Loop Simulation	190-122	130
Helmet Mounted Display System	190-131	132
Human Interface with Intelligent Fault Management Systems	190-85	107
Intelligent Assistants Technology – Human Interface Guidelines	190-86	108
Mission Evaluation Room Advanced Automation Project (MAAP)	190-135	135
Model and Simulation for FTS Control Station Testbed and Brassboard	190-83	159
Multi-arm Robot Control Environment	190-41	85
Orbiter and Space Station Control Station Breadboard	190-82	128
Override Demonstration	190-129	131
Planetary Surface Systems HART Systems Engineering Studies	190-154	82
Procedural Reasoning System	190-71	158
RMS Advanced Closed Loop Control	190-65	97
Redundant Manipulator Kinematics	190-155	83
Robotic Arms for Manipulating Equipment During Thermal Vacuum Tests	190-48	145
Robotic Gripper Controller Development	190-120	75
Robotic Vision/Tracking Sensors	190-77	125
Robotics Research Arm Advanced Controller Implementation	190-124	78
Simulation of Robotics Space Operations	190-36	144
Smart Electromechanical Attenuator/Actuator for SS Docking/Berthing	190-136	141
Smart Robotic Hand for EVA Operations	190-44	116
Space Station Health Exercise Monitoring and Control System	190-59	93
Space Station Operations Management System	190-137	79
Structural Assembly, Berthing, and Manufacturing Support	190-139	141
Task Level Robot Programming for EVA Retriever Simulation	190-61	153
Verification and Validation of Rule Based Systems	190-138	139
Vision for Grasping for EVA Retriever	190-63	156
Vision for the EVA Retriever	190-62	155

190-120

Title:
Robotic Gripper Controller Development

Description:
Redesign, develop, implement, and checkout a replacement electronic controller for a mechanical parallel jaw gripper with force sensing in each parallel jaw. Incorporate a single board computer (SBC), with an A/D converter and electronics for a power controller, to control the gripper

Program: Advanced Programs Date: Jan 90

Point of Contact: John Chladek Telephone: 483-1528
Division: ER - Automation and Robotics
Branch: Robotic Systems Development
Section: Teleoperated Robots

State: in use

Categories Describing the Work of this Project:

1.3 Actuation and manipulation
2.4 Robotic and telerobotic systems

1.3-7 End effectors
1.3-8 Manipulators
2.4-6 Servicing and repair

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
8 Full operational capability (incorporated in production design)

Performing Organizations	Name of Contact	Telephone
Lockheed Engineering & Sciences Company	Perry Campbell	(713) 333-6665

Current Status:
The controller has been completed and installed on the Robotics Research 1607 arm. The system is being replicated for use on grippers on Puma and Robotics Research 2107 arms.

Schedule:
The initial gripper and arm have been completed.

190-121

Title:
Dual Actuator Robotic Joint Mechanism

Description:
Study, build, and test a manipulator with dual motor, encoder, brake, and gear train redundancy and an independent controller for each side. Minimization of weight is a prime driver.

Program: Shuttle

Date: Jan 90

Point of Contact: John Chladek

Telephone: 483-1528

Division: ER - Automation and Robotics
Branch: Robotic Systems Development
Section: Teleoperated Robots

State: Active

Categories Describing the Work of this Project:

1.3 Actuation and manipulation
1.2 Sensing

1.3-2 Arms
1.3-4 Compliance
1.3-5 Control technology
1.3-8 Manipulators
1.2-7 Force and torque
1.2-13 Temperature

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
1 Basic principle observed or reported

Performing Organizations	Name of Contact	Telephone
University of Texas at Austin	Dr. Delbert Tesar	(512) 471-3039

Current Status:
The project has just been initiated.

Schedule:
Actuator/module design: Sep 90
Actuator/module prototype: Sep 91

190-123

Title:
Advanced Force/Torque Control Study for the RMS System

Description:
Adapt force and torque data from the sensor on the arm end effector for use in a closed-loop control system on the RMS system. The system parameters must be modeled, and the parameters of the test manipulator system determined, to allow modification of control concepts. The Robotic Research arm will act like a long flexible manipulator arm, as the RMS responds.

Program: Shuttle

Date: Jan 90

Point of Contact: John Chladek
Division: ER - Automation and Robotics
Branch: Robotic Systems Development
Section: Teleoperated Robots

Telephone: 483-1528

State: Active

Categories Describing the Work of this Project:

1.2 Sensing
1.3 Actuation and manipulation
1.4 Human-machine interface

1.2-7 Force and torque
1.3-2 Arms
1.3-4 Compliance
1.3-5 Control technology
1.4-3 Feedback of force and torque
1.4-4 Fusion of sensors

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Performing Organizations	Name of Contact	Telephone
Lockheed Engineering & Sciences Company	Thuy Nguyen	(713) 333-7241

Current Status:
Parameters of the Robotics Research RR1607 robot have been acquired and modeled. Force and torque control have been implemented. Selected control laws will be tested on the RR1607 robot.

Schedule:
The project was completed December 1989.
Selected control laws will be implemented at the MDF facility at JSC by December 1990.

190-124

Title:
Robotics Research Arm Advanced Controller Implementation

Description:
Incorporate an advanced internal control computer into the commercial controller from Robotics Research. Replace the analog electronics for the servo controller with digital signal processing (DSP). This will provide a research and development platform for pursuit of issues in advanced control of force and torque, contact, and compliance.

Program: Advanced Programs Date: Jan 90

Point of Contact: John Chladek Telephone: 483-1528
Division: ER - Automation and Robotics
Branch: Robotic Systems Development
Section: Teleoperated Robots

State: Active

Categories Describing the Work of this Project:

1.3 Actuation and manipulation
1.4 Human-machine interface
2.1 Supporting software and hardware

1.3-5 Control technology
1.4-7 Management of user interfaces
2.1-2 Distributed systems

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
2 Conceptual design formulated

Performing Organizations	Name of Contact	Telephone
Lockheed Engineering & Sciences Company	James Hwang	(713) 333-6370

Current Status:
Installation and checkout of the internal control computer is 80 percent complete. Replacement of the digital signal processor is 40 percent complete.

Schedule:
It is expected that the project will be completed and ready for use in development by June 1990.

190-137

Title:
Space Station Operations Management System

Description:
Define the partitioning of functions of distributed subsystems of the Space Station in a scenario for an expert system for management of operations aboard the Space Station. Partitioning methods were developed during the first two years of the study. Techniques formulated will be evaluated during the final two years (FY89, 90). Subsystem cooperation and interdependence will be demonstrated.

Program: Space Station
NASA Headquarters Program Code: RC

Date: Apr 90

Point of Contact: Allan E. Brandli
Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Onboard Systems Management

Telephone: 483-8238

State: Active

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems

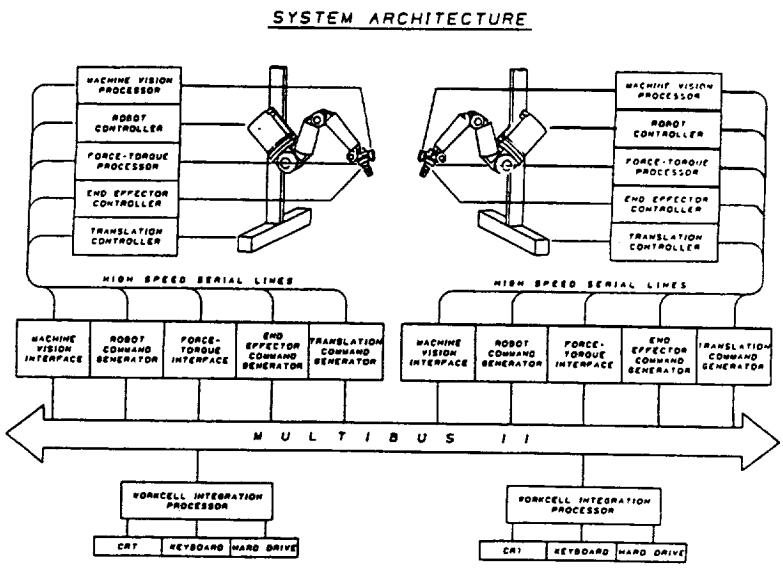
Funded: yes

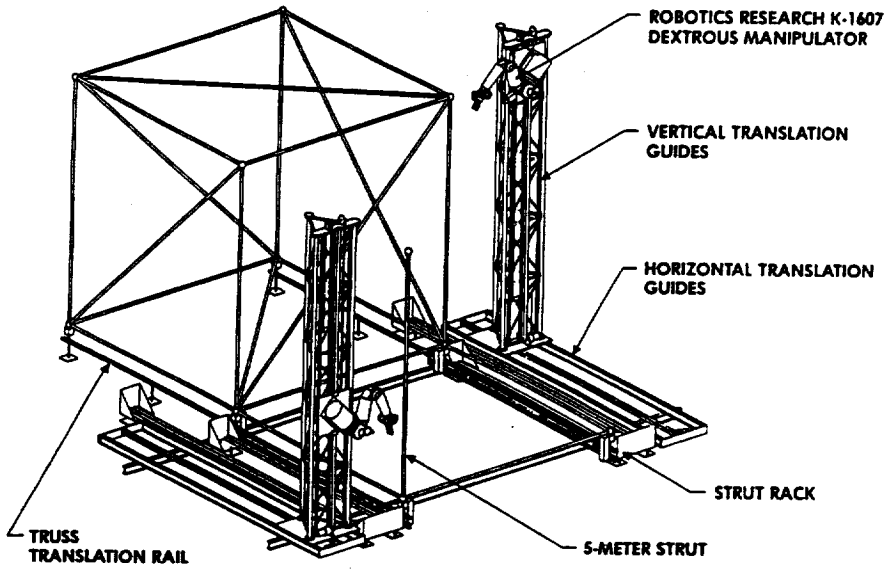
Expected Level of Technology at the End of the Fiscal Year:
3 Conceptual design tested

Performing Organizations	Name of Contact	Telephone
TRW	Roscoe Lee	(713) 333-3133
TRW	Doug Rue	(713) 333-3133

Current Status:
The project is active, funded, and progressing.

Schedule:
Objectives and constraints of partitioning and criteria for evaluation will be developed further. Trade studies of partitioning will use RTOP methods and tools. A reference architecture will be formulated for applications and systems management for Space Station GN&C. An example is partitioning of traffic management functions among computers dedicated to traffic management, and core GN&C and ground computers.





190-144 Automated robotic assembly of Space Station.

190-144

Title:
Automated Robotic Assembly of Space Station

Description:
Demonstrate, in 1g, in a work cell representative of the Orbiter cargo bay, the robotic assembly of full scale Space Station structure. Develop designs for structural fastening, for tasks related to WP02 mechanical and structural systems, that are compatible with assembly and maintenance by robots. Use JSC test facilities in developing, integrating, and evaluating proof-of-concept structural hardware.

Program: Space Station
UPN/PWC: 472-46-0717

Date: Feb 90

Point of Contact: LeBarian Stokes
Division: ER - Automation and Robotics
Branch: Robotic Systems Evaluation
Section: Robotic Applications Laboratories

Telephone: 483-8965

State: Active

Categories Describing the Work of this Project:

2.4 Robotic and telerobotic systems
1.3 Actuation and manipulation
2.1 Supporting software and hardware
2.2 System design and integration

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
2 Conceptual design formulated

Performing Organizations	Name of Contact	Telephone
Lockheed Engineering & Sciences Company	Monty B. Carroll	(713) 333-6805

Current Status:
Laboratory prototypes of candidate structural fasteners that are compatible with robots have been fabricated. Detailed design of the x-y platform of the work cell is near completion. Integration of the work cell controller, including the force and torque sensor, end-effector, vision system, and work cell integration computer system, is ongoing.

Schedule:
Evaluation and fabrication of structural fasteners: Feb 89 - Nov 90
Design and fabrication of end-effectors: May 90 - Nov 90
Design and fabrication of ASSAP (Automated Space Structures Assembly Platform): Jun 89 - Oct 90
Integration of the control system: Feb 89 - Oct 90 Demonstration and test of robotic assembly: Dec 90 - May 91

190-154

Title:
Planetary Surface Systems HART Systems Engineering Studies

Description:
The objective is to conduct the systems engineering, especially trade studies, to provide understanding of the operations and design aspects of human roles, automation, robotics, and telerobotics (HART) for all planetary surface systems to optimize the total systems and operations. Reports of studies are due in December 1990.

Program: Space Exploration Initiate
NASA Headquarters Program Code:
UPN/PWC: 326-84

Date: May 90

Point of Contact: Jon D. Erickson
Division: ER - Automation and Robotics
Branch:
Section:

Telephone: 483-1508

State: Active

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems
2.4 Robotic and telerobotic systems

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
1 Basic principle observed or reported

Performing Organizations	Name of Contact	Telephone
Lockheed Engineering & Sciences Company	Dale Phinney	(713) 333-6712

Current Status:
Activity began in March 1990.

Schedule:

190-155

Title:
Redundant Manipulator Kinematics

Description:
Analyze the redundant DOF of a Robotic Research K1607 manipulator. Integrate criteria for optimization into the testbed. Use analysis of the rate control law and performance to evaluate the optimization criteria. Use the redundant analysis in simulating the manipulator. Analyze the rate control law and performance of the redundant DOF; use orbit modes for preliminary POR and avoidance of arm linking.

Program: OSF Advanced Program Development
NASA Headquarters Program Code: MD
UPN/PWC: 906-22-02

Date: June 4, 1990

Point of Contact: Les Quiocho
Division: ER - Automation and Robotics
Branch: Robotic Systems Evaluation
Section: Robotic Applications Laboratories

Telephone: 483-8633

State: Active

Categories Describing the Work of this Project:

1.3 Actuation and manipulation

1.3-3 Collision avoidance
1.3-5 Control technology
1.3-8 Manipulators

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Performing Organizations	Name of Contact	Telephone
LINCOM	Robert W. Bailey	(713) 488-5700

Current Status:
A subtask that developed out of the original implementation was started in October 1989. Rate control laws and performance with redundant degrees of freedom are being analyzed, and control of dual arms is being coordinated

Schedule:
The task was initiated in July 1989.
Collision detection and avoidance completed: October 1989.
Demonstration of the concept: December 1989.

190-156

Title:
Dynamic Modeling of 6+ DOF Robotic Manipulator Systems

Description:
Develop a dynamic simulation to enhance the real-time dynamic capabilities of JSC in-house manipulator software packages. An efficient set of equations of motion has been developed for a manipulator with n rotational DOF attached to a 6 DOF free space base. The application independent equations are generalized for any revolute manipulator and result in real-time performance on a UNIX workstation.

Program: OSF Advanced Program Development
NASA Headquarters Program Code: MD
UPN/PWC: 906-22-02

Date: June 4, 1990

Point of Contact: Les Quiocho
Division: ER - Automation and Robotics
Branch: Robotic Systems Evaluation
Section: Robotic Applications Laboratories

Telephone: 483-8633

State: Active

Categories Describing the Work of this Project:

1.3 Actuation and manipulation

1.3-8 Manipulators

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Performing Organizations	Name of Contact	Telephone
LINCOM	Robert W. Bailey	(713) 488-5700

Current Status:
The project is active. The algorithm has been applied to various manipulator systems, including those with servo motor math modeling, redundant arm controller, and base digital auto plot (DAP) controller.

Schedule:
The algorithm has been applied to various manipulator systems, including those with servo motor math modeling, redundant arm controller, and base digital auto plot (DAP) controller.

190-41

Title:
Multi-arm Robot Control Environment

Description:
Control a pair of RTX robot arms with open architecture; examine a variety of control environments including Ada; use real input data in relevant timing studies. Simulate and demonstrate the algorithms necessary to provide real-time (80 msec) coordinated control of two manipulators operating in a common environment.

Program: OSF Advanced Program Development
NASA Headquarters Program Code: MD
UPN/PWC: 906-22-02

Date: June 4, 1990

Point of Contact: Les Quiocho
Division: ER - Automation and Robotics
Branch: Robotic Systems Evaluation
Section: Robotic Applications Laboratories

Telephone: 483-8633

State: low level

Categories Describing the Work of this Project:

1.3 Actuation and manipulation

1.3-5 Control technology
1.3-6 Coordination
1.3-8 Manipulators

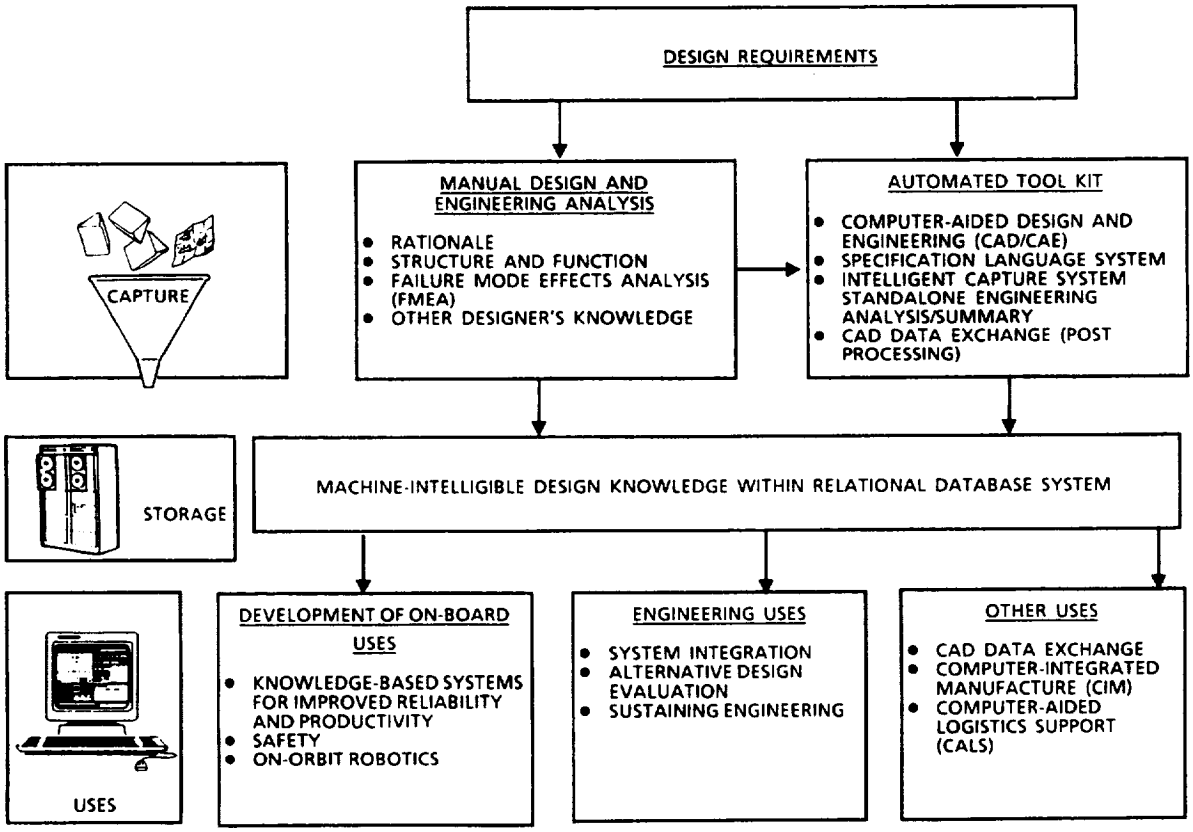
Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Performing Organizations	Name of Contact	Telephone
LINCOM	Robert W. Bailey	(713) 488-5700

Current Status:
Two subtasks that developed out of the original implementation have been completed. The telerobotic OMV with aerodynamics and gravity gradient has been integrated with pre-existing stand-along models. Hardware components been integrated with the simulation of the coordinated dual-arm RTX; software models of servo motors have replaced hardware, and control of the two arms has been coordinated.

Schedule:
The project has been completed.



190-53 Design knowledge capture.

190-53

Title:
Design Knowledge Capture

Description:
Design, develop, and demonstrate a Design Knowledge Support system to capture, organize, and provide access to design knowledge related to the design, development, testing, integration, and operation of Space Station Freedom. Coordinate with and advise the Functional Area Manager for Design Knowledge Capture (DKC) for Work Package 2. Produce a plan for DKC that covers Work Package 2 and JSC Level III.

Program: Space Station

Date: Jan 90

Point of Contact: K. Crouse
Telephone: 483-2040
Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Advanced Automation

State: Active

Categories Describing the Work of this Project:

1.1 Knowledge

1.1-1 Acquisition of knowledge

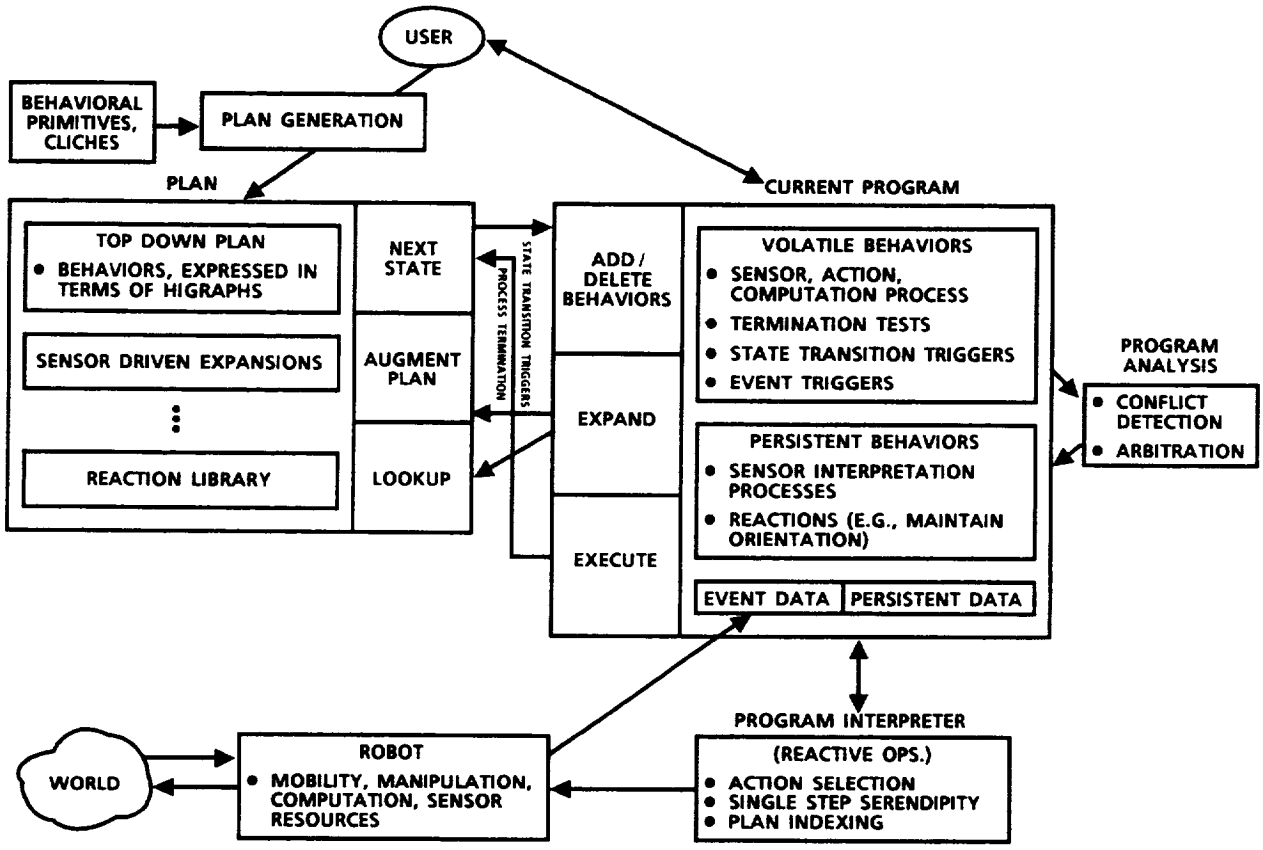
Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
2 Conceptual design formulated

Performing Organizations	Name of Contact	Telephone
Lockheed Engineering & Sciences Company	Ralph Krog	(713) 333-6345
Barrios Technology Inc.	Robert Hennan	(713) 280-1839

Current Status:
A plan for Design Knowledge Capture for Work Package 2 and JSC is being updated. Hardware and software for the Design Knowledge Support System have been acquired; design and development of the initial system has begun. Capturing of design decisions and rationale during the SSF Preliminary Design Review is being planned; operational capture of design information from other sources is being implemented.

Schedule:
Begin operational capture of rationale: Spring 1990
Demonstrate Phase 2 of the development of the Design Knowledge Support System: Sep 90



190-57 Architecture for semi-autonomous planning.

190-57

Title:
Architectures for Semi-Autonomous Planning

Description:
Develop and deliver software for the EVA Retriever, and integrate it into the EVA Retriever. The software will provide a high-level architecture to enable reactive generation and execution of plans and instruction of humans by the robot through a vocabulary of reactive procedures to achieve plans for use in dynamic, unrestricted, real world space environments.

Program: SBIR 87-2 Date: January 1990
NASA Headquarters Program Code: CR
UPN/PWC: 324-02-EF-02

Point of Contact: Jon D. Erickson Telephone: 483-1508
Division: ER - Automation and Robotics

State: Active

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems

2.3-10 Planning

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
5 Component or breadboard tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
Advanced Decision Systems	Dr. Dan Shapiro	(415) 960-7300

Current Status:
Two quarterly reports have been received. The work is on schedule.

Schedule:
Demonstration of software using simulation at the end of the first year. Two demonstrations on the EVA Retriever, one at 18 months and one at the end of the second year.

This page intentionally left blank.

190-58

Title:
AI Systems for Monitoring and Control

Description:
Develop and evaluate methods for effective use of an AI shell called EAGOL in manned space applications. A major feature of the resulting intelligent system is that it reasons along with the human and incorporates the human's reasoning and knowledge in selection of goals, reasoning, and planning responses.

Program: SBIR 89-2 Date: January 1990
NASA Headquarters Program Code: CR
UPN/PWC: 324-01-88-05

Point of Contact: Jon D. Erickson Telephone: 483-1508
Division: ER - Automation and Robotics

State: Active

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems
1.1 Knowledge

2.3-10 Planning
1.1-9 Planning
1.1-12 Representation and reasoning

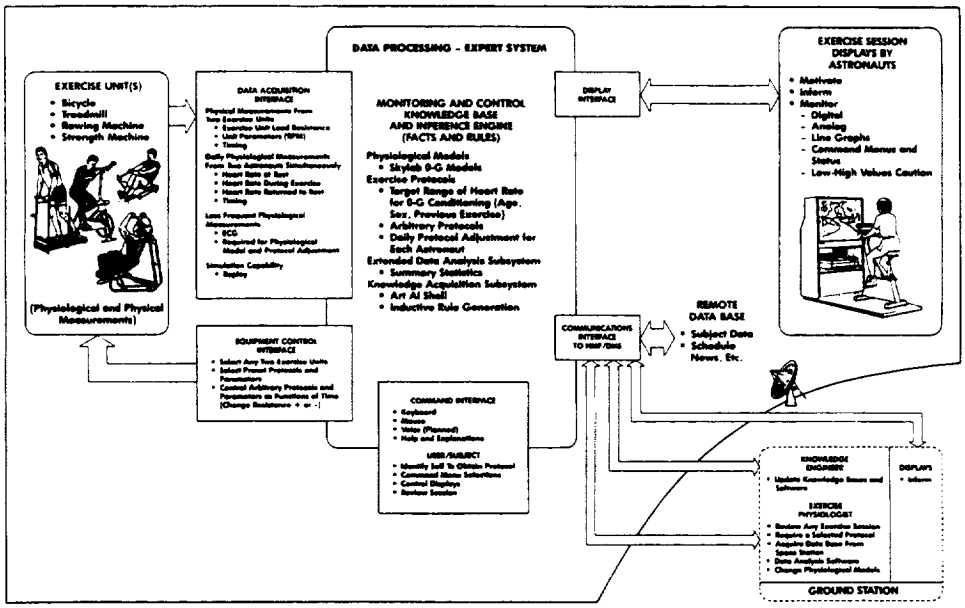
Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Performing Organizations	Name of Contact	Telephone
Seer Systems, Incorporated	Dr. Harry E. Pople, Jr.	(412) 366-4502

Current Status:
The contract may start in March 1990. This project is part of a joint project of EF and DF on the Payload Deployment and Retrieval System.

Schedule:
Demonstrations are scheduled at 3 months, 12 months, 18 months, and 23 months after start of the contract.



190-59 Space Station health exercise monitoring and control system.

190-59

Title:
Space Station Health Exercise Monitoring and Control System

Description:
Develop a knowledge based monitoring and control system to support the design of the Health Exercise Monitoring and Control System to analyze non-invasive measurements of decondi-tioning and advise exercise countermeasures aboard the Space Station. The system will be used to generate specifications for integrating a medically oriented symbolic processing system into the Space Station Data Management System.

Program: NASA Space Medicine Data Analysis Date: Jan 90
NASA Headquarters Program Code: EB
UPN/PWC: 199-70-31-11
Task no.: 25-5X0A

Point of Contact: Laurie Webster Telephone: 483-2034
Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Advanced Automation

State: Active

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems
1.1 Knowledge
1.4 Human-machine interface

2.3-9 Monitoring
2.3-3 Distributed expert systems
2.3-7 Interacting expert systems
1.1-1 Acquisition of knowledge
1.1-4 Diagnosis
1.4-6 Interfaces to knowledge based or expert systems

Funded: yes

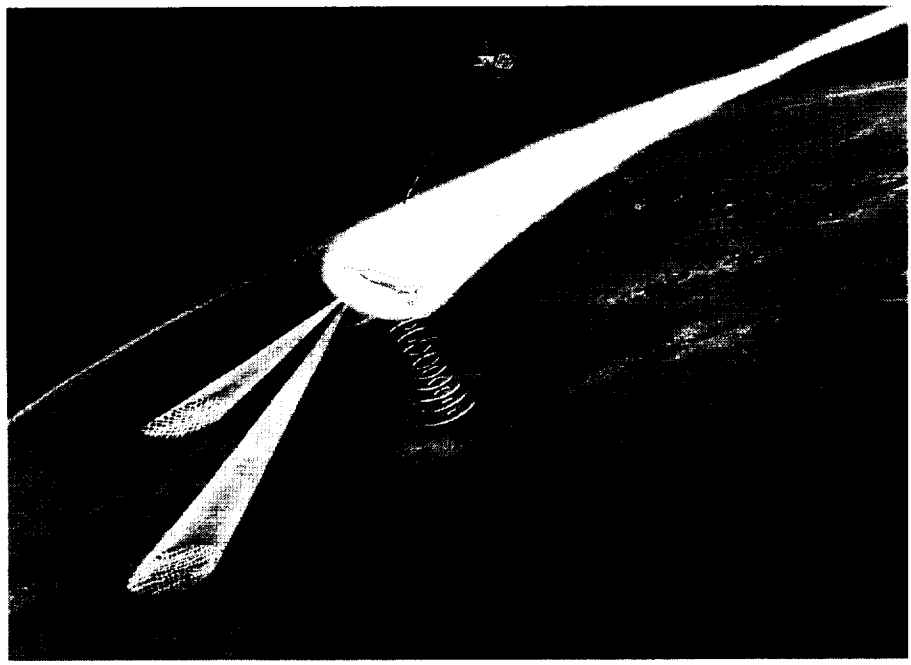
Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
Lockheed Engineering & Sciences Company	Dale Phinney	(713) 333-6712

Current Status:

The hardware for the knowledge based system and a software prototype have been integrated into a system using distributed processing. A 386 microcomputer and a Lisp machine control the user interface and provide voice synthesis, displays, storage of data, planning, executive control, and management of resources. A SUN-4 graphical workstation provides an analysis oriented interface for the exercise physiologist.

Schedule:
A peer review is planned at the end of FY90.



190-64 Autonomous lander for planetary exploration.

190-64
Title:
Autonomous Lander for Planetary Exploration

Description:
The objective is to develop a capability to land a spacecraft safely and accurately near targets of interest despite rough terrain. JSC is the coordinating center in support of project management at Headquarters; ARC, JPL, and JSC participate technically. In FY90 JSC will do feasibility studies and systems engineering of real-time hazard detection and avoidance aboard the entry and landing vehicle.

Program: Pathfinder
NASA Headquarters Program Code: R
UPN/PWC: 591-13

Date: Aug 30, 89

Point of Contact: Ken Baker
Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Automated Robotics

Telephone: 483-2041

State: Active

Categories Describing the Work of this Project:

2.4	Robotic and telerobotic systems
1.1	Knowledge
1.2	Sensing
1.4	Human-machine interface

2.4-3	Computer vision systems
1.1-11	Recognition of objects
1.1-14	Simulation
1.2-11	Range and rate
1.2-14	Visual and optical
1.4-4	Fusion of sensors

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
2 Conceptual design formulated

Performing Organizations	Name of Contact	Telephone
Draper Laboratory	Tim Brand	(617) 258-2429
Lockheed Engineering & Sciences Company	Dan Tuckness	(713) 333-7376
Environmental Research Institute of Michigan	M. Trichel	(703) 528-5250

Current Status:
Initial analysis shows that, given adequate guidance and control performance and a sufficiency small map error, it should be possible to navigate accurately enough to land within several kilometers of a preselected target. A geologically based Mars terrain model and an initial model for computing the probability of safe landing have been developed. A feasibility study of on-board hazard detection has begun.

Schedule:
FY90: Requirements defined and approaches for in-depth development selected.
FY92/93: Initial Phase of technology development complete.
FY93/94: Autonomous landing technology evaluated in a testbed.
FY94/95: One-G flight tests of autonomous landing.

This page intentionally left blank.

190-65

Title:
RMS Advanced Closed Loop Control

Description:
Use sensors and algorithms developed by OAST to demonstrate advanced closed loop control of the Shuttle RMS and the utility for teleoperation (shared control) and telerobotics (traded control) of feedback of force and torque. Use the Manipulator Development Facility and the Systems Engineering Simulator at JSC in modifying procedures for the RMS to utilize the feedback of force and torque.

Program: CSTI
NASA Headquarters Program Code: RC
UPN/PWC: 590-02-11-01

Date: Jan 18, 1990

Point of Contact: Gerald J. Reuter
Division: ER - Automation and Robotics
Branch: Robotic Systems Evaluation
Section: Robotic Utilization

Telephone: 483-1520

State: Active

Categories Describing the Work of this Project:

1.3 Actuation and manipulation
1.2 Sensing

1.3-5 Control technology
1.3-7 End effectors
1.3-8 Manipulators
1.2-7 Force and torque
1.2-8 Integrating sensor information

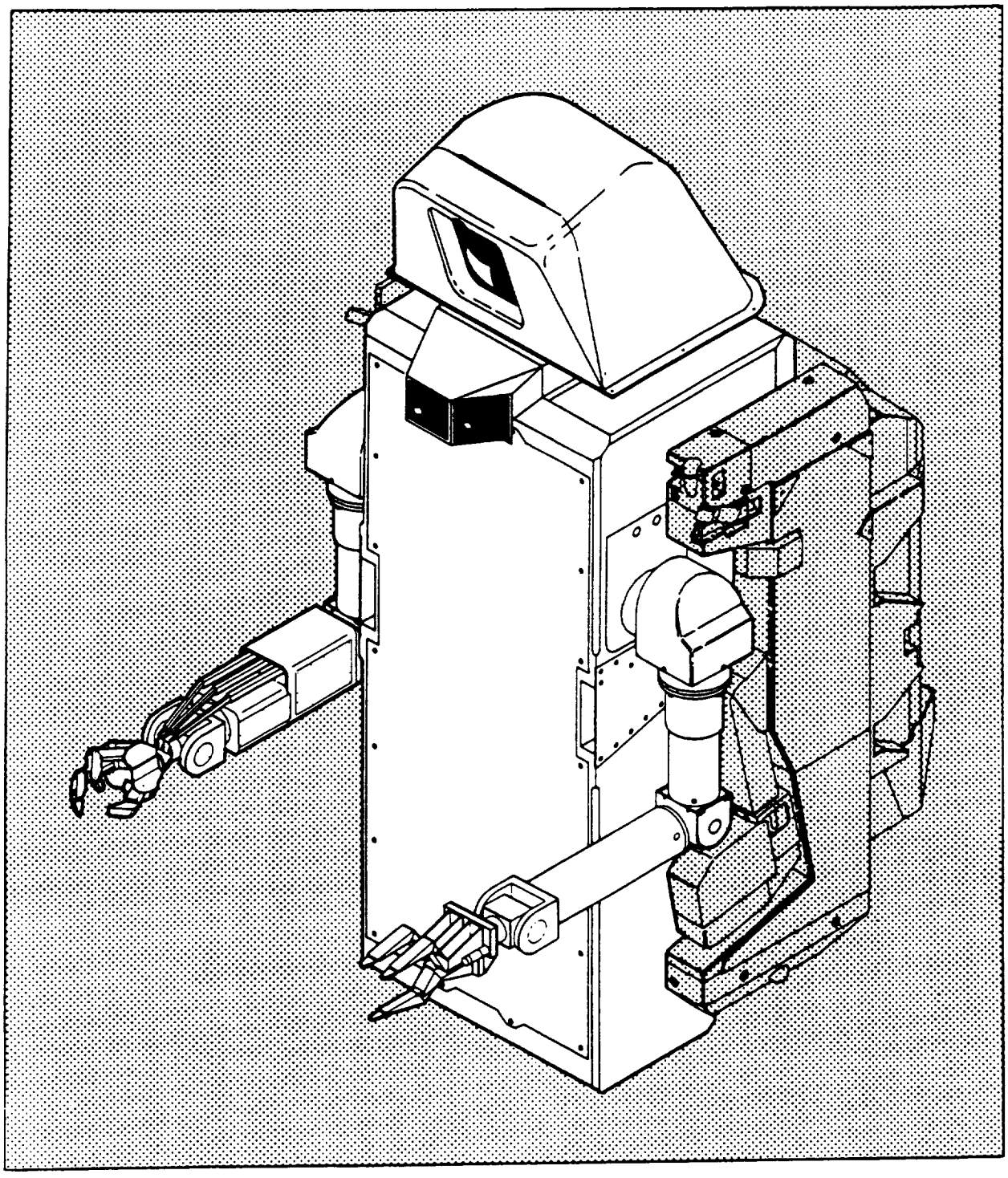
Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Performing Organizations	Name of Contact	Telephone
Lockheed Engineering & Sciences Company	Thuy Nguyen	(713) 333-7241

Current Status:
A demonstration of an impedance control algorithm utilizing a Robotics Research 1607 manipulator was presented to the Telerobotic Intercenter Working Group. A closed-loop control capability is being implemented in the manipulator development facility.

Schedule:
This is a 3 year project beginning in FY89 and continuing through FY91.



190-66 EVA retriever ground demonstration.

190-66

Title:
EVA Retriever Ground Demonstration

Description:
Integrate the work or five Divisions on the EVA Retriever, an autonomous robotic system for rescuing crew members or retrieving equipment in space: Systems Development and Simulation, Crew and Thermal Systems, Tracking and Communications, Avionic Systems, and Structures and Mechanics. End products will be the ground demonstration, technical reports, software system modules, and analyses of operations.

Program: EVA Retriever, Dir's Discretionary Fund — Date: Jan 18, 1990
NASA Headquarters Program Code:
UPN/PWC: 307-51-67-20
Task no.: 3

Point of Contact: Cliff Hess — Telephone: 483-9142
Division: ER - Automation and Robotics
Branch: Robotic Systems Development
Section: Autonomous Robots

State: Active

Categories Describing the Work of this Project:

2.4 Robotic and telerobotic systems

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
3 Conceptual design tested

Performing Organizations	Name of Contact	Telephone
Lockheed Engineering & Sciences Company	Gene Miller	(713) 333-6164
GHG Corp	Doug Walker	(713) 483-0992
Lockheed Engineering & Sciences Company	Robert Norsworthy	(713) 333-6240

Current Status:
Integration of Phase 2 is in progress. Testing of Phase 2 on the precision air bearing floor is scheduled for February and March 1990.

Schedule:
Electrical integration of major components: FY87
Software is operational: FY90
Autonomy augmented: FY91

This page intentionally left blank.

190-68

Title:
Advanced Development for Space Robotics

Description:
Develop an advanced precision, dexterous, 8 DOF carbon fiber manipulator that will be modular and layered. Perform research in mechanisms, real time computation, fault tolerant architecture, adaptive control, and metrology for advanced robotics. Develop advanced actuators, a universal manual controller, control of dual arms for assembly, and metrology of manipulators.

Program: CSTI
NASA Headquarters Program Code: RC
UPN/PWC: 590-02-71-0

Date: Jan 90

Point of Contact: Gerald J. Reuter
Division: ER - Automation and Robotics
Branch: Robotic Systems Evaluation
Section: Robotic Utilization

Telephone: 483-1520

State: Active

Categories Describing the Work of this Project:

1.3 Actuation and manipulation
2.1 Supporting software and hardware
2.2 System design and integration
2.3 Knowledge based or expert systems

1.3-8 Manipulators
1.3-1 Actuation in expert systems
2.1-3 Fault-tolerant architecture
2.2-7 Environments for automation
2.3-1 Control
2.3-10 Planning

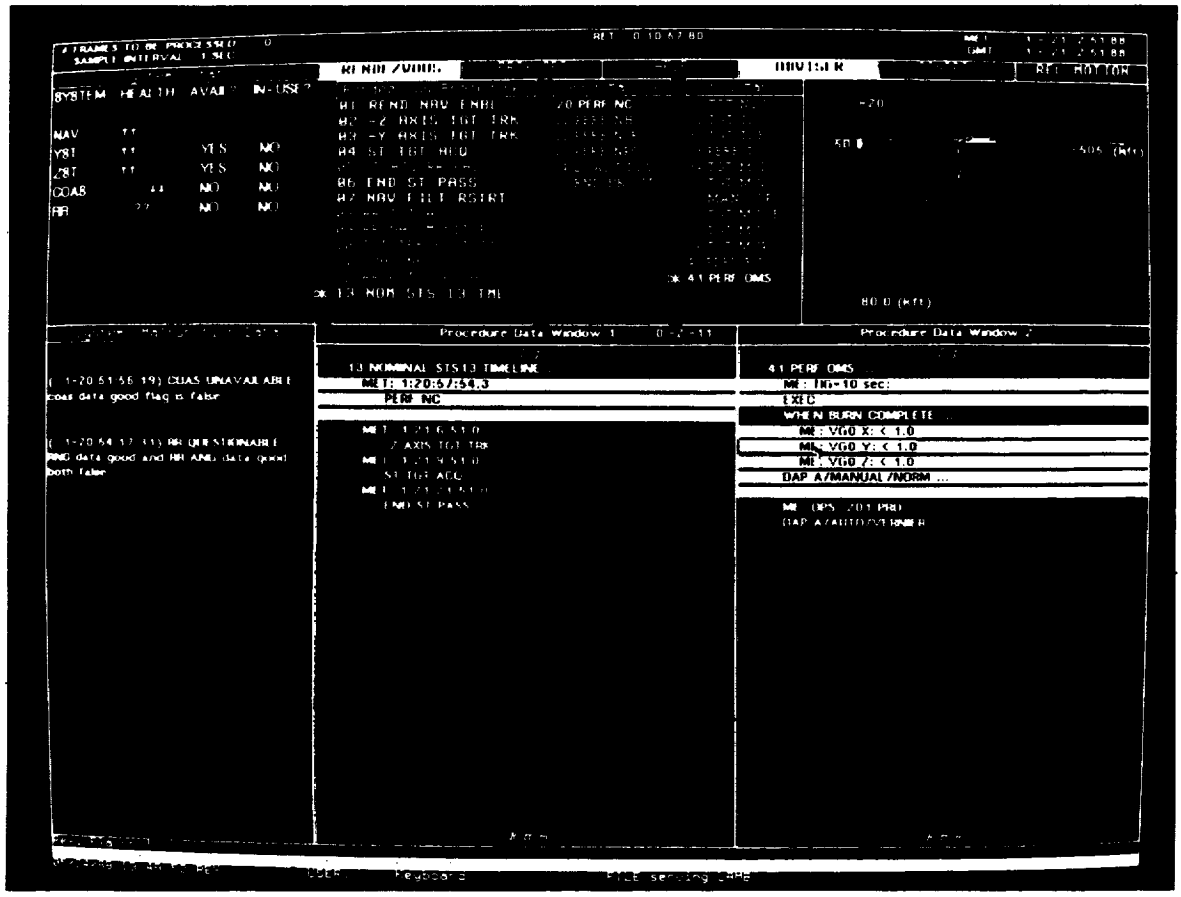
Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
2 Conceptual design formulated

Performing Organizations	Name of Contact	Telephone
University of Texas at Austin	Dr. Delbert Tesar	(512) 471-3039

Current Status:
Funding has been received. A Purchase Request is in the system.

Schedule:
The research is to be performed over a period of 60 months.



190-70 Export system for execution of crew procedure.

190-70

Title:
Expert System for Execution of Crew Procedures

Description:
The Rendezvous Expert System (REX), developed to advise the crew during rendezvous with other orbiting bodies, was interfaced with the Systems Engineering Simulator (SES) and demonstrated using a typical rendezvous scenario. The REX will be augmented with a control mode to allow the expert system to control the simulated flight system and an expert system for proximity operations will be implemented.

Program: OSF Advanced Programs
NASA Headquarters Program Code: MD
UPN/PWC: 906-21-03

Date: Jan 90

Point of Contact: H. K. Hiers
Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Advanced Automation

Telephone: 483-2036

State: Active

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems
1.4 Human-machine interface
1.1 Knowledge

2.3-9 Monitoring
2.3-13 Sequencing
1.1-1 Acquisition of knowledge
1.1-7 Monitoring
1.4-1 Controls
1.4-2 Displays

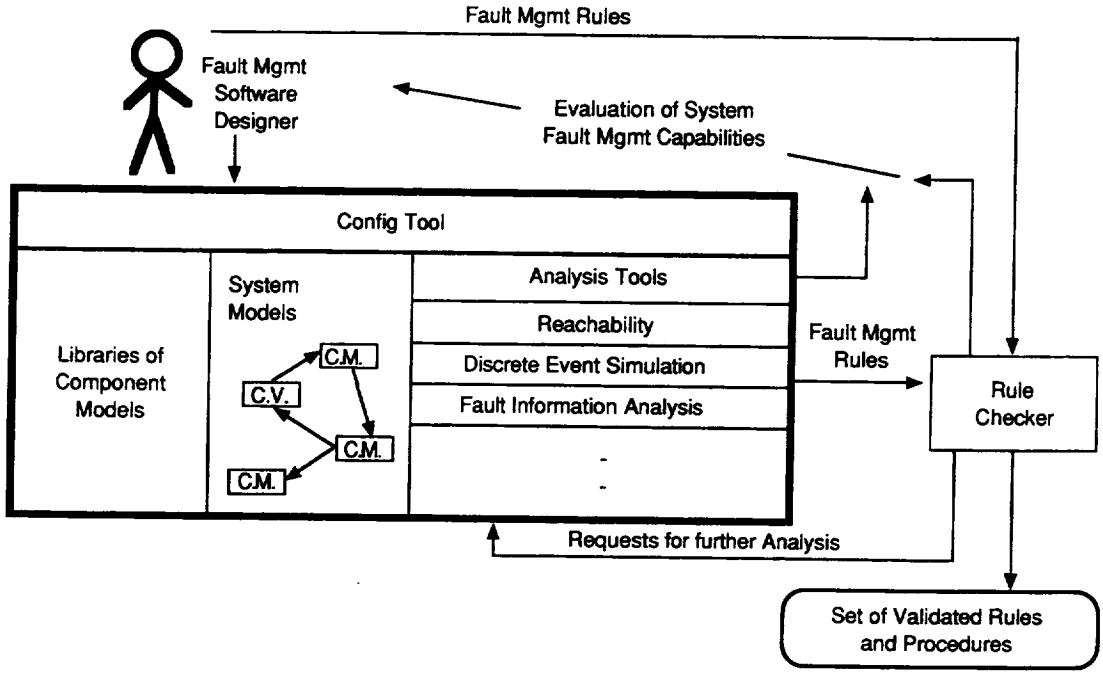
Funded: yes

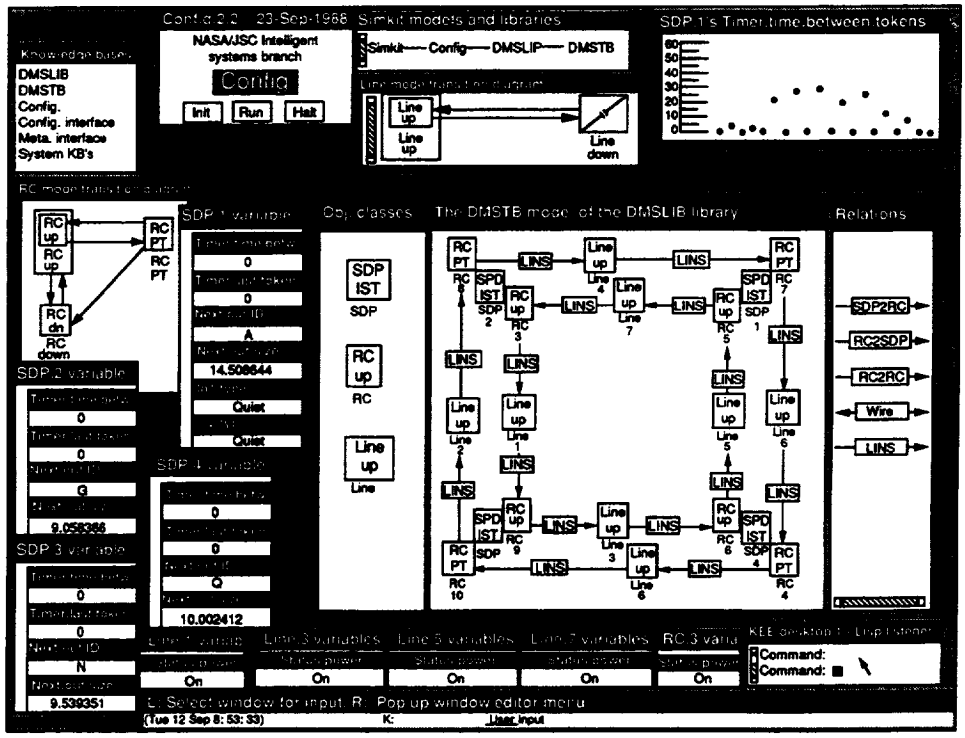
Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
Lockheed Engineering & Sciences Company	Oscar Olszewski	(713) 333-6218

Current Status:
Implementation of the Phase I REX is complete. The project plan for the Crew Procedure Expert System has been completed. A stand-alone demonstration of REX Proximity Operations has been completed.

Schedule:
Definition of requirements: Aug 89
Demonstration of REX control mode: Feb 90
Demonstration of laser-augmented Prox-Ops: June 90





190-84 CONFIG: Qualitative and discrete event fault management analysis tools.

190-84

Title:
CONFIG: Qualitative and Discrete Event Fault Management Analysis Tools

Description:
Prototype tools for modeling, simulation, and analysis to support engineering of space systems for effective fault management, and for understanding of systems. Integrate qualitative modeling, discrete event simulation, graph analysis, and interactive graphics, to provide an easy-to-use tool for analyzing designs, developing and validating fault management software, and supporting real-time fault management.

Program: Space Station Freedom

Date: Jan 90

Point of Contact: Jane T. Malin, Ph.D.
Telephone: 483-2046
Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Advanced Automation

State: Active

Categories Describing the Work of this Project:

2.2 System design and integration
2.3 Knowledge based or expert systems
1.4 Human-machine interface

2.2-2 Aids for design
2.2-8 Knowledge engineering
2.2-10 Validation and verification
2.3-8 Management of faults
1.4-6 Interfaces to knowledge based or expert systems

Funded: yes

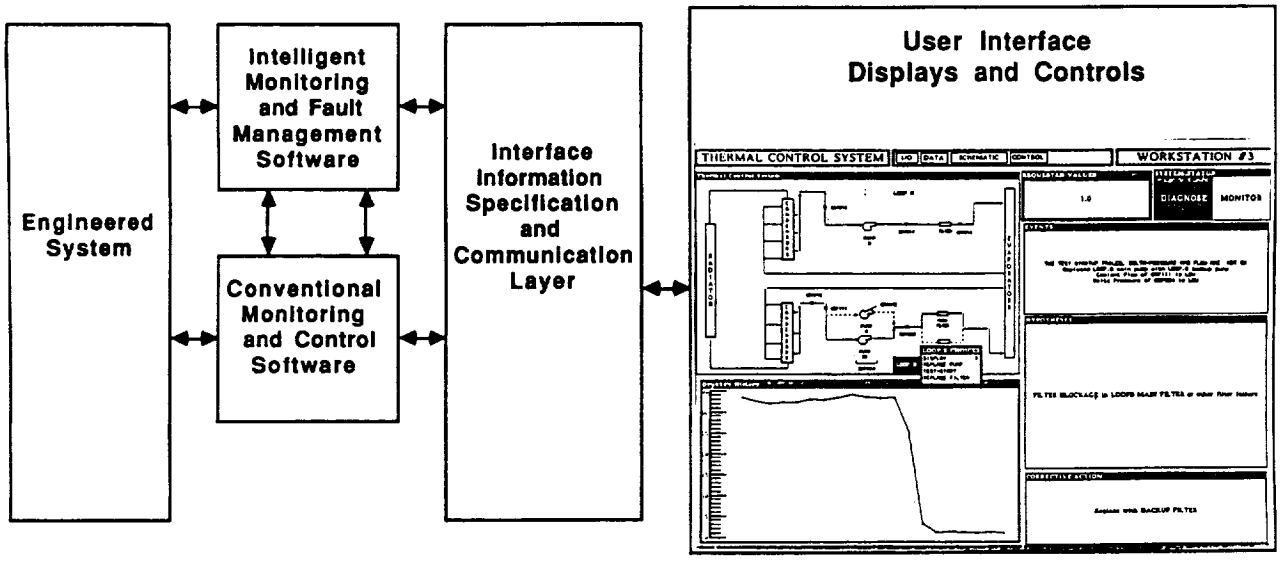
Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

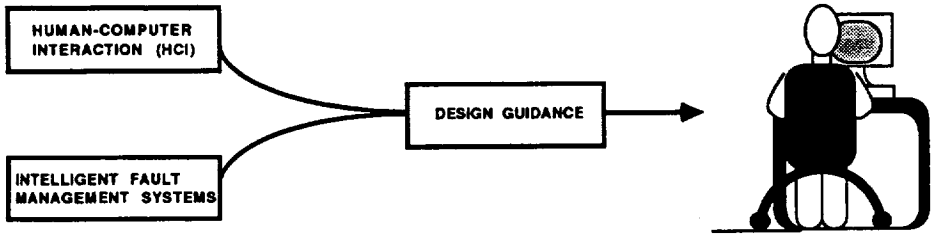
Performing Organizations	Name of Contact	Telephone
The MITRE Corporation	James C. Reynolds	(713) 333-0956

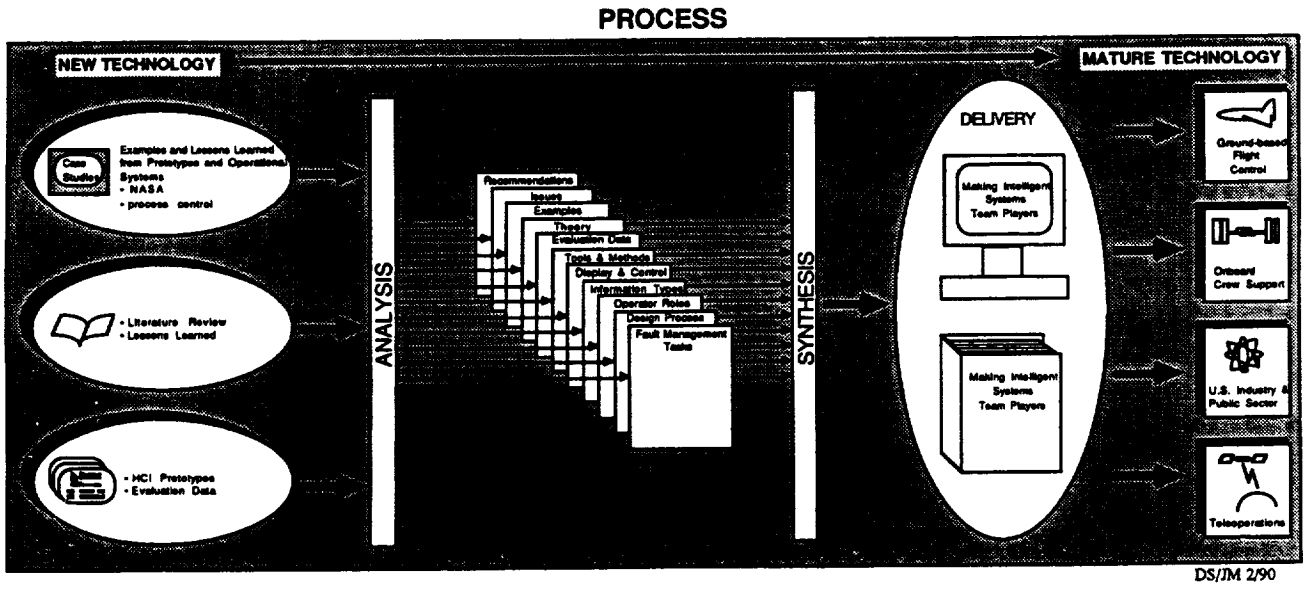
Current Status:
Version 2.2 models and simulates dynamic processing systems. Limited field tests include modeling and analysis of fault management of space station computer networks and of failures and their effects in PDRS subsystems. A software patent is pending. A chapter on CONFIG in Artificial Intelligence in Process Engineering is in press. Requirements and design for reimplementation are being analyzed.

Schedule:
Version 3: Reimplimentation with enhancements to support development of fault management software and provide additional capabilities for modeling and simulation - Complete May 91
Application of CONFIG to model STS PDRS to support development of failure analyzer expert system - Complete May 91

C-2.







190-85 Human interface with intelligent fault management systems.

190-85

Title:
Human Interface with Intelligent Fault Management Systems

Description:
Investigate the use of schematics and diagrams in interfaces between humans and model-based intelligent systems for monitoring and management of faults in engineered systems. Develop advanced concepts, guidelines, user-interface prototypes, and tools for constructing interfaces that use graphics and schematic diagrams to explain decisions, plans, and reasoning of intelligent systems.

Program: OAST RTOP
NASA Headquarters Program Code: RC
UPN/PWC: 506-47-11-01

Date: Jan 90

Point of Contact: Jane T. Malin, Ph.D.
Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Advanced Automation

Telephone: 483-2046

State: Active

Categories Describing the Work of this Project:

1.4 Human-machine interface
2.3 Knowledge based or expert systems

1.4-2 Displays
1.4-6 Interfaces to knowledge based or expert systems
1.4-7 Management of user interfaces
2.3-8 Management of faults
2.3-9 Monitoring

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Performing Organizations	Name of Contact	Telephone
IntelliCorp	Karen Kessel	(415) 965-5500
The MITRE Corporation	James C. Reynolds	(713) 333-0956

Current Status:
The prototype and methodology for the User-System Interface Construction Tool have been designed. An initial implementation has been completed and applied to a fault management scenario for a thermal control system. A demonstration of the use of diagrams in a human interface system for explaining the reasoning of intelligent systems has been completed.

Schedule:
Demonstrate the prototype User-System Interface Construction Tool
and deliver it to the Human-Computer Interaction Laboratory - March 90
Report on the design of the human interface with intelligent systems - April 90
Proposal for evaluation and enhancement of the Tool Prototype - May 90
Report on the case study of developing interface requirements - Sep 90

190-86

Title:
Intelligent Assistants Technology – Human Interface Guidelines

Description:
Define the context for design of interfaces between humans and intelligent systems for fault management. Identify candidate guidelines and open research issues on intelligent systems: information needed from the systems and its display, requirements for design of the systems, and of systems for managing the user interface. Develop concepts for improved approaches to guiding and aiding design.

Program: OAST CSTI RTOP
NASA Headquarters Program Code: RC
UPN/PWC: 590-12-32-02

Date: Jan 90

Point of Contact: Jane T. Malin, Ph.D.
Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Advanced Automation

Telephone: 483-2046

State: Active

Categories Describing the Work of this Project:

1.4 Human-machine interface
2.3 Knowledge based or expert systems

1.4-2 Displays
1.4-6 Interfaces to knowledge based or expert systems
1.4-7 Management of user interfaces
2.3-8 Management of faults
2.3-9 Monitoring

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
1 Basic principle observed or reported

Performing Organizations	Name of Contact	Telephone
The MITRE Corporation	James C. Reynolds	(713) 333-0956
University of Illinois	Kenneth Forbus,Ph.D.	
Ohio State University	David Woods, Ph.D.	

Current Status:
This is a new project.

Schedule:
Nov 89: Project plan. Sep 90: JSC, OSU, and University of Illinois Reports: Space-domain fault management and design of human interface with intelligent systems, space-domain intelligent fault management systems and requirements for effective human interfaces, and human interface with space-domain intelligent fault management systems and requirements for model-based system design, respectively.

190-88

Title:
Advanced Automation Methodology Project

Description:
Develop a viable methodology for software engineering that will apply for the entire life cycle of applications of advanced automation. A standard methodology, the Software Management and Assurance Program (SMAP), will be used in developing two applications. The methodology will be changed as appropriate to the applications being developed, and all changes will be documented in a final integrated approach.

Program: Space Station Freedom
NASA Headquarters Program Code: SS

Date: Jan 90

Point of Contact: Ginger Pack
Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Advanced Automation

Telephone: 483-1515

State: Active

Categories Describing the Work of this Project:

2.2 System design and integration
2.1 Supporting software and hardware
1.1 Knowledge

2.2-6 Automation of engineering
2.2-2 Aids for design
2.1-2 Distributed systems
2.1-6 Specialized architecture for artificial intelligence
1.1-1 Acquisition of knowledge
1.1-5 Execution

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
Level not given

Performing Organizations	Name of Contact	Telephone
The MITRE Corporation	Tammy Pelnik	

Current Status:
The project is ongoing.

Schedule:
Delivery of the final document on methodology: December 1990

This page intentionally left blank.

190-89

Title:
Advanced Automation Network Monitoring System

Description:
The Advanced Automation Network Monitoring System (AANMS) will provide continuous monitoring in real time of a testbed, created in the Intelligent Systems Laboratory, for an FDDI (Fiber Distributed Data Interface) network. It will be capable of identifying system faults and advising the operator of correct operations for recovery.

Program: Space Station Freedom — Date: Jan 90
NASA Headquarters Program Code: SS

Point of Contact: Dennis Lawler — Telephone: 483-2037
Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Advanced Automation

State: Active

Categories Describing the Work of this Project:

2.2 System design and integration
1.1 Knowledge
2.1 Supporting software and hardware

2.2-6 Automation of engineering
1.1-1 Acquisition of knowledge
1.1-7 Monitoring
1.1-4 Diagnosis
2.1-2 Distributed systems
2.1-6 Specialized architecture for artificial intelligence

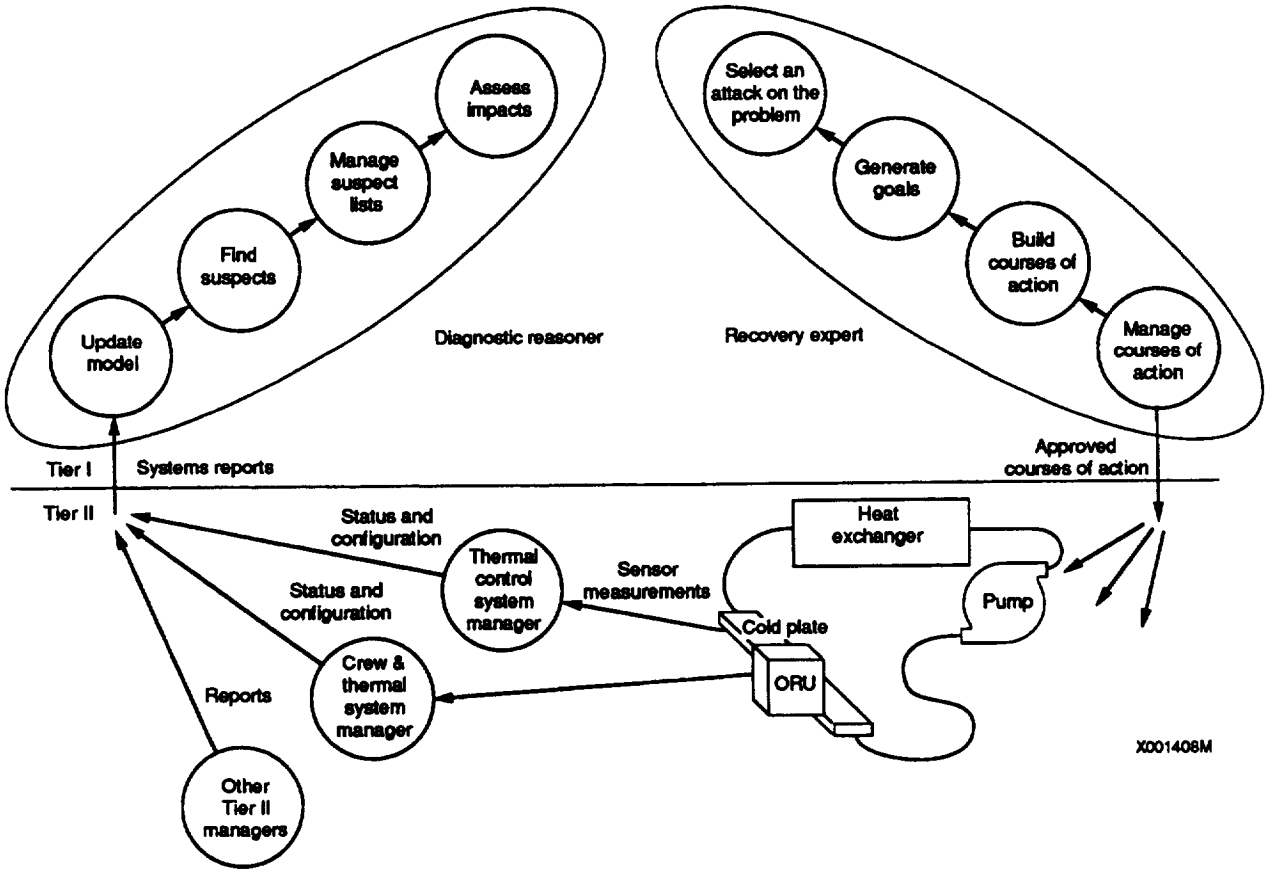
Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Performing Organizations	Name of Contact	Telephone
Lockheed Engineering & Sciences Company	Boris Freydin	(713) 333-6571

Current Status:
Requirements are being developed.

Schedule:
Delivery of the initial demonstration: December 1990



190-90 Diagnostic reasoner/recovery expert.

190-90

Title:
Diagnostic Reasoner/Recovery Expert

Description:
The Integrated Status Assessment (ISA) prototype will be enhanced to include the Diagnostic Reasoner, for diagnosis of faults in complex distributed systems, and the Recovery Expert prototype, that uses procedural knowledge in replanning of operations on Space Station Freedom. The enhancements will be build on the foundation of earlier work on ISA.

Program: Space Station Freedom
NASA Headquarters Program Code: SS
Date: Jan 90

Point of Contact: Dennis Lawler
Telephone: 483-2037
Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Advanced Automation

State: Active

Categories Describing the Work of this Project:

1.1 Knowledge
2.3 Knowledge based or expert systems
2.1 Supporting software and hardware

1.1-4 Diagnosis
1.1-5 Execution
1.1-12 Representation and reasoning
2.1-6 Specialized architecture for artificial intelligence
2.1-3 Fault-tolerant architecture

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Performing Organizations	Name of Contact	Telephone
The MITRE Corporation	Chris Marsh	(713) 333-0984

Current Status:
The project started October 1, 1989. Development of scenarios for use in definition of conceptual requirements is underway. Development of the architecture has started.

Schedule:
Delivery of software for demonstration: August 1, 1990

190-91

Title:
Functional Area Manager for Work Package 2 Advanced Automation

Description:
General support in system engineering and integration will be provided to any organizational element of Level II or Level III of Work Package 2 of the Space Station Freedom Program using or affecting technology for advanced automation.

Program: Space Station Freedom Date: Jan 90

Point of Contact: Dennis Lawler Telephone: 483-2037
Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Advanced Automation

State: Active

Categories Describing the Work of this Project:

2.1 Supporting software and hardware
2.2 System design and integration
2.3 Knowledge based or expert systems
1.1 Knowledge

2.1-1 Accommodation for automation & robotics in design
2.2-6 Automation of engineering
1.1-4 Diagnosis
1.1-7 Monitoring
1.1-13 Search techniques

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
Level not given

Performing Organizations	Name of Contact	Telephone
Lockheed Engineering & Sciences Company	Ralph Krog	(713) 333-6345

Current Status:
The project is ongoing.

Schedule:
Ongoing.

190-92

Title:
Active Thermal Control System – Simulation and Fault Management

Description:
Demonstrate the feasibility of end-to-end integration of engineering simulations into applications of advanced automation for flight and ground support of detection, isolation, and recovery of faults on orbit. The focus is on demonstrating this capability for the Thermal Control System for Space Station Freedom. This project is a direct follow-on of the TEXSYS system autonomy demonstration.

Program: Space Station Freedom Adv. Dev. Date: Jan 90
NASA Headquarters Program Code: SS
UPN/PWC:
Task no.: 1

Point of Contact: Dennis Lawler Telephone: 483-2037
Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Advanced Automation

State: Active

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems
1.1 Knowledge
1.3 Actuation and manipulation
1.4 Human-machine interface

2.3-1 Control
2.3-9 Monitoring
2.3-7 Interacting expert systems
1.1-12 Representation and reasoning
1.3-1 Actuation in expert systems
1.4-6 Interfaces to knowledge based or expert systems

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
Lockheed Engineering & Sciences Company	Edmund Hack	(713) 333-6658

Current Status:
The concept is being defined.

Schedule:
Jun 90: Definition of requirements for the high fidelity simulation.
Jul 90: Development of the low fidelity simulation.
Oct 90: Completion of the interface design.
Nov 90: System integration and demonstration
Dec 90: Final report delivered

190-44

Title:
Smart Robotic Hand for EVA Operations

Description:
Use techniques of artificial intelligence in developing algorithms for using tactile and proximity sensors for autonomous grasping and manipulation of objects of various shapes. The algorithms will be applicable to the five types of robotic hands being procured or fabricated by the Crew and Thermal Systems Division. Verify the algorithms experimentally.

Program: EVA Retriever
UPN/PWC: 307–51
Task no.: 1

Date: Jan 90

Point of Contact: Cliff Hess
Division: ER - Automation and Robotics
Branch: Robotic Systems Development
Section: Autonomous Robots

Telephone: 483-9142

State: Active

Categories Describing the Work of this Project:

1.3 Actuation and manipulation
2.4 Robotic and telerobotic systems
1.2 Sensing

1.2-8 Integrating sensor information
1.3-5 Control technology
1.3-7 End effectors
1.3-8 Manipulators
2.4-5 Handling of parts
2.4-7 Retrieval and rescue

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Current Status:
A Jameson 6 degree-of-freedom robotic hand has been fabricated and integrated with the EVA Retriever Ground Demonstration System. Control and proximity sensing have been developed using the Utah/MIT robotic hand, and autonomous grasping using proximity, and force and position sensors has been demonstrated.

Schedule:
FY88: Integrate the programs for control of the hands with sensors for position and force. Establish a test bed for a smart hand.
FY89: Integrate the algorithms with the software for control of the EVA Retriever hands.
FY90: Evaluate and demonstrate the hand system on the Precision Air Bearing Floor as part of the EVA Retriever system.

190-45

Title:
Free-Flyer/Robotic Arm Positioning Techniques

Description:
Develop techniques for control of the cooperative movements of robotic systems with multiple articulating elements that must function together to achieve a single goal (e.g., MMU, arm, and hand). Using an AI approach, emulate the human response and optimize the coordinated positioning of the MMU, robotic arms, and hands to allow grappling of selected targets.

Program: EVA Retriever
UPN/PWC: 307-51
Task no.: 2

Date: June 89

Point of Contact: Cliff Hess
Telephone: 483-9142
Division: ER - Automation and Robotics
Branch: Robotic Systems Development
Section: Autonomous Robots

State: Active

Categories Describing the Work of this Project:

1.3 Actuation and manipulation

1.3-2 Arms
1.3-6 Coordination
1.3-8 Manipulators
1.3-9 Propelling mechanisms

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
3 Conceptual design tested

Current Status:
The interaction of the MMU and the arms was evaluated during the Phase I test of the EVA Retriever. An improved arm design and control system have been developed to provide finer positioning and greater range of motion than was possible with the hardware of the Phase I configuration The Phase II hardware has been integrated with that of the EVA Retriever for testing on the air bearing floor at JSC.

Schedule:
FY88: Study the interactions of the three systems on the Air Bearing Floor, and develop a simulation of the integrated system.
FY89: Integrate the system with the EVA Retriever.
FY90: Evaluate and demonstrate the capabilities using the EVA Retriever on the Precision Air Bearing Floor.

This page intentionally left blank.

190-46

Title:
Free-Flyer/Fault Detection and Correction System

Description:
Develop an expert system for tasks normally done by the MMU pilot: detection and correction of faults. The expert system, in addition to self testing and checkout, will continuously monitor the health of the MMU and the status of consumables it carries. The expert system will allow the MMU to be used as a carrier for the EVA retriever, a free-flying robot.

Program: EVA Retriever
UPN/PWC: 307-51
Task no.: 3

Date: Jan 90

Point of Contact: Cliff Hess
Telephone: 483-9142
Division: ER - Automation and Robotics
Branch: Robotic Systems Development
Section: Autonomous Robots

State: Active

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems
2.2 System design and integration

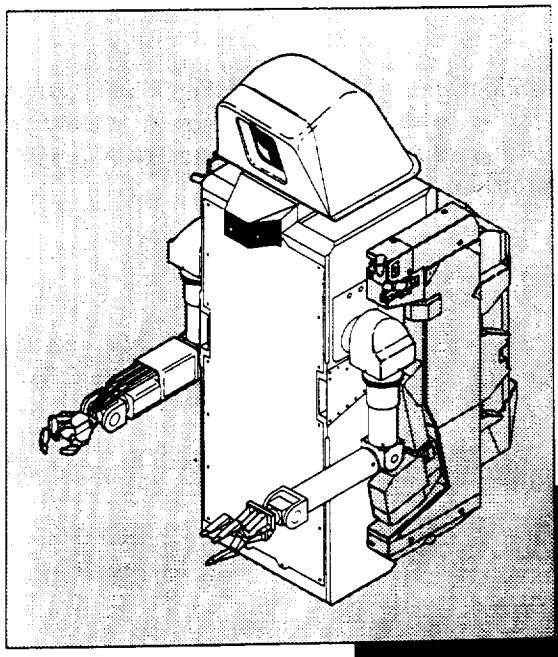
2.3-8 Management of faults
2.3-9 Monitoring

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Current Status:
During development of the knowledge base, rules used for training the crew in the detection of faults in the MMU have been coded. A system for simulating and testing a system for detection and correction of faults has been developed; development of software has been completed. Hardware and software are being configured for incorporation in the EVA Retriever.

Schedule:
FY88: Develop the expert system and requirements for associated sensors and actuators.
FY89: Develop a simulation of the system.
FY90: Integrate the expert system with the EVA Retriever to provide detection and correction of faults in the MMU system. Demonstrate performance on the Precision Air Bearing Floor.



Phase 2 EVA retriever configuration

Phase I EVA retriever system

190-47 EVA retriever test bed.

190-47

Title:
EVA Retriever Test Bed

Description:
Integrate the subsystems of the EVA Retriever into a test bed compatible with the MMU, for dynamic testing on the JSC Precision Air Bearing Floor.

Program: EVA Retriever
UPN/PWC: 307–51
Task no.: 4

Date: Jan 90

Point of Contact: Cliff Hess
Division: ER - Automation and Robotics
Branch: Robotic Systems Development
Section: Autonomous Robots

Telephone: 483-9142

State: Active

Categories Describing the Work of this Project:

2.2 System design and integration

2.2-7 Environments for automation
2.2-10 Validation and verification

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
5 Component or breadboard tested in the relevant environment

Current Status:
The Phase I hardware has been integrated and tested on the air bearing floor. Phase II hardware with increased capabilities has been integrated for testing on the air bearing floor.

Schedule:
FY88: Evaluate the performance of the EVA Retriever under software control on the air bearing floor.
FY89: Upgrade the EVA Retriever system for Phase II testing.
FY90: Perform Phase II testing on the Precision Air Bearing Floor.

This page intentionally left blank.

190-69

Title:
Fault Tolerant Manipulator and Proof of Concept

Description:
The goal is to develop a three-string fault-tolerant architecture for manipulator systems with redundant motors that will satisfy requirements for reliability that include no single point failures. Failures will be fail-safe/fail-operational.

Program: CSTI Date: Jan 90
NASA Headquarters Program Code: RC
UPN/PWC: 590-02-71-02

Point of Contact: Gerald J. Reuter Telephone: 483-1520
Division: ER - Automation and Robotics
Branch: Robotic Systems Evaluation
Section: Robotic Utilization

State: Active

Categories Describing the Work of this Project:

2.1 Supporting software and hardware
1.3 Actuation and manipulation
2.2 System design and integration
1.4 Human-machine interface

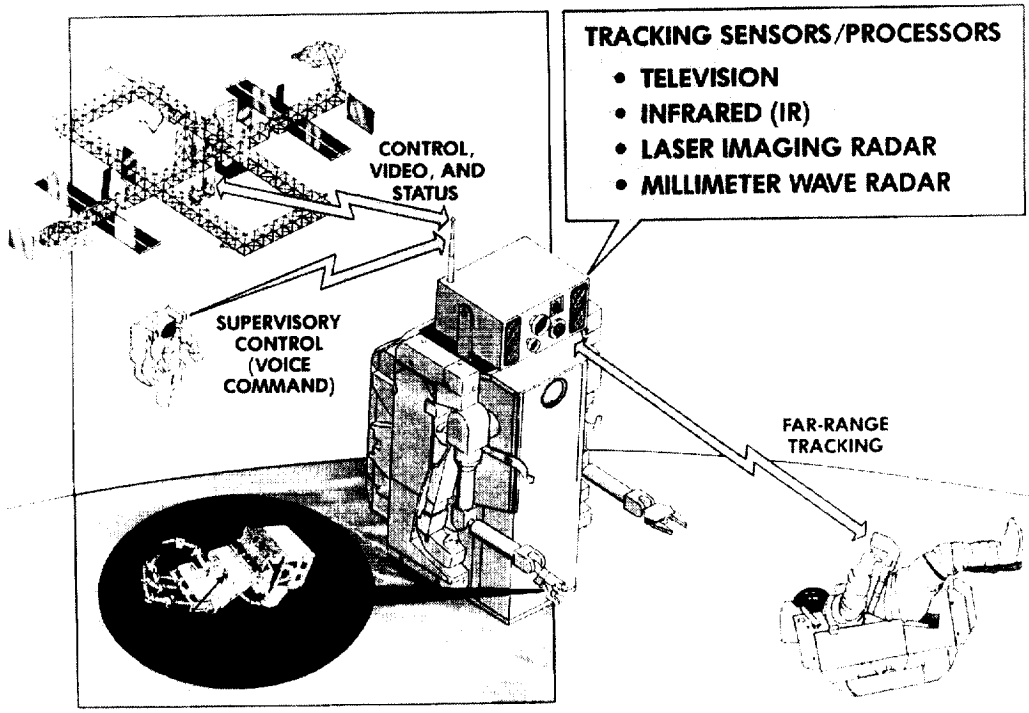
2.1-3 Fault-tolerant architecture

Funded: yes

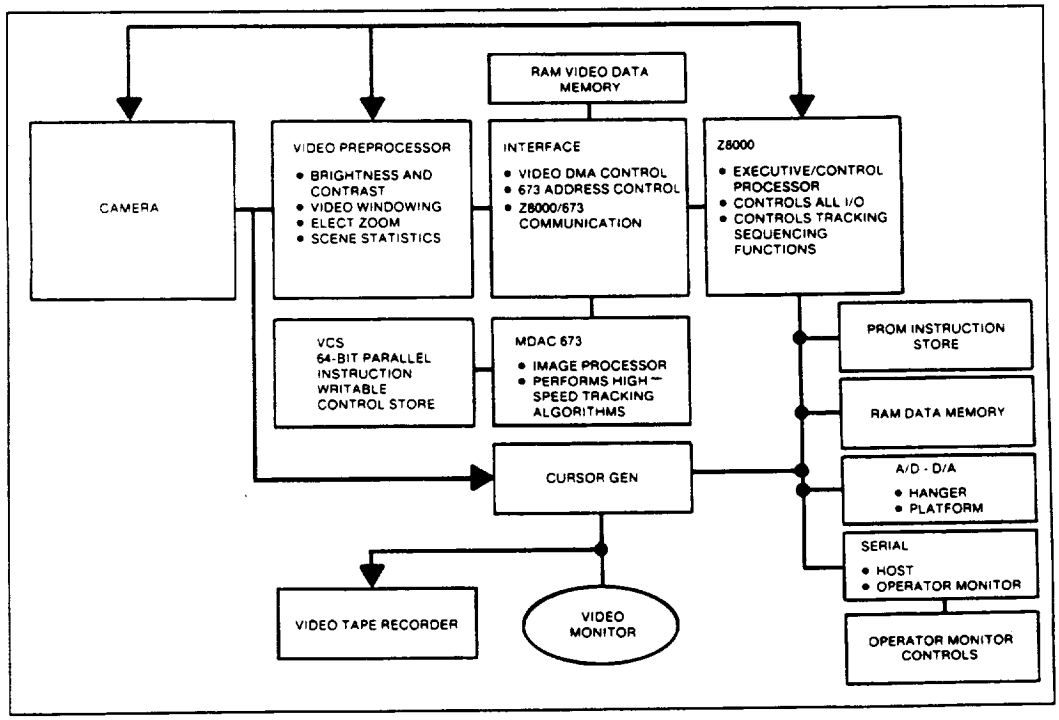
Expected Level of Technology at the End of the Fiscal Year:
5 Component or breadboard tested in the relevant environment

Current Status:
The preliminary concept has been defined.

Schedule:
The research will be performed over a period of three years.



Architecture of the multimode tracker.



190-77 Robotic vision/tracking sensors.

190-77

Title:
Robotic Vision/Tracking Sensors

Description:
Develop, test, and evaluate sensors, techniques of sensor fusion, and algorithms for use in identification and tracking of targets and images to support spaceborne robots, robotic manipulators, and spacecraft during servicing of satellites and other proximity operations. Sensors to be evaluated include video, infrared, and laser vision and tracking.

Program: Advanced Programs
NASA Headquarters Program Code: M
UPN/PWC: 906-30-03-30

Date: Jan 1, 1990

Point of Contact: Donald E. Rhoades
Division: ER - Automation and Robotics
Branch: Robotic Systems Development
Section: Autonomous Robots

Telephone: 483-1457

State: Active

Categories Describing the Work of this Project:

1.2 Sensing
1.1 Knowledge
2.4 Robotic and telerobotic systems

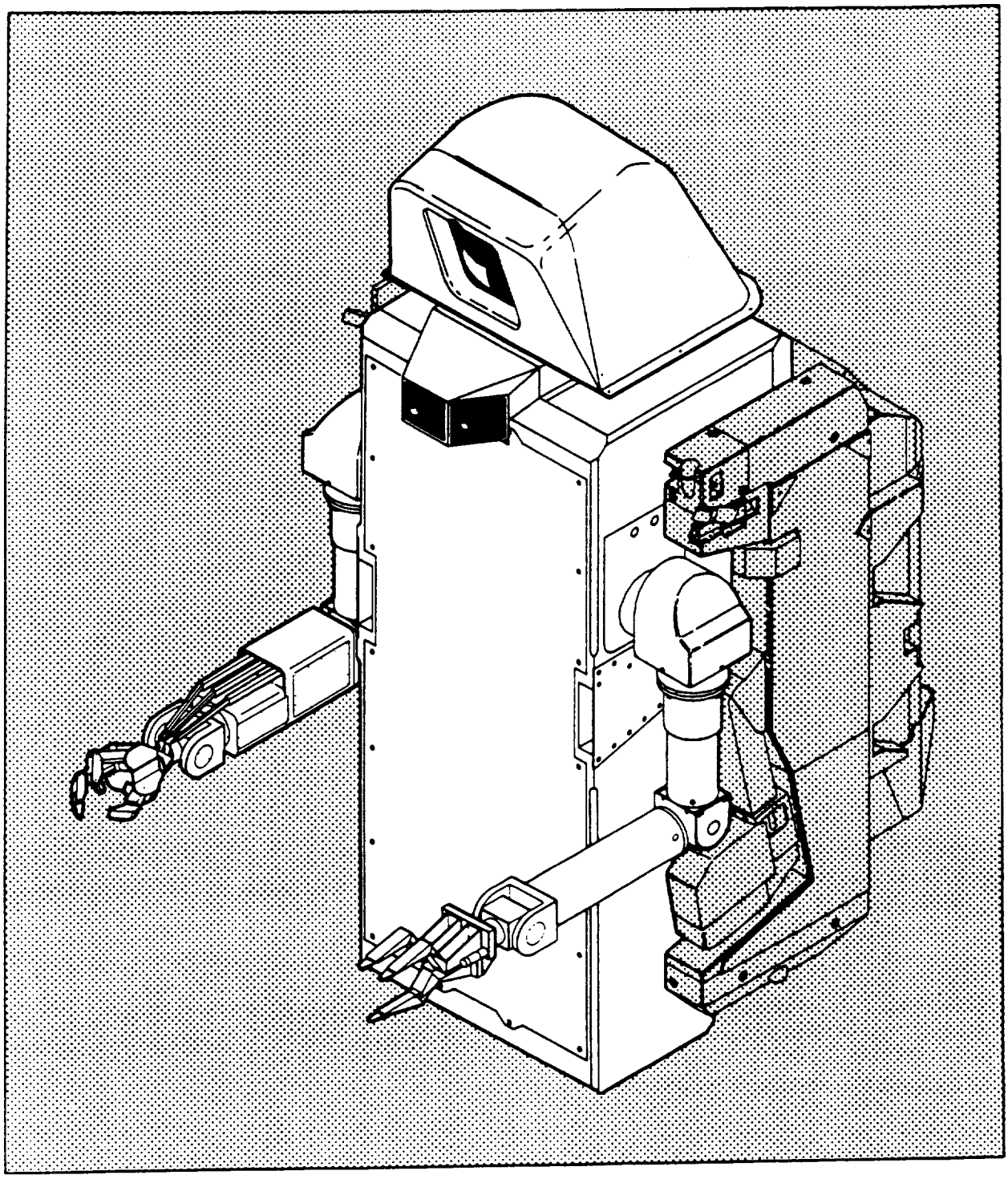
1.2-11 Range and rate
1.2-14 Visual and optical
1.1-11 Recognition of objects
2.4-2 Automatic inspection
2.4-3 Computer vision systems
2.4-7 Retrieval and rescue

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Current Status:
The updated video tracker and the 3-D lidar have been integrated into the Phase II EVA Retriever ground demonstration. Software has been developed for avoiding obstacles and grasping the target using 3-D data. Two new video processing vision systems for object recognition and tracking are available.

Schedule:
Phase II EVA Retriever demonstration: May 1990
3-D target recognition software: July 1990
Evaluation of two new processors: September 1990



190-78 EVA retriever vision/tracking system.

190-78

Title:
EVA Retriever Vision/Tracking System

Description:
Develop a vision-based target recognition and tracking system for the EVA Retriever. Its will recognize targets autonomously, track targets for rendezvous, determine size and orientation of targets to be grappled, and provide information about obstacles. This is a three phase, three year program to develop a ground demonstration to prove the concept for applications for future flight programs.

Program: Director's Discretionary Fund
NASA Headquarters Program Code:
UPN/PWC: 307-51-67-20

Date: Jan 90

Point of Contact: Donald E. Rhoades
Division: ER - Automation and Robotics
Branch: Robotic Systems Development
Section: Autonomous Robots

Telephone: 483-1457

State: Active

Categories Describing the Work of this Project:

2.4 Robotic and telerobotic systems
1.1 Knowledge
1.2 Sensing
1.3 Actuation and manipulation

2.4-3 Computer vision systems
1.1-8 Perceptual reasoning
1.1-11 Recognition of objects
1.2-11 Range and rate
1.2-14 Visual and optical
1.3-3 Collision avoidance

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Current Status:
Upgraded hardware has been integrated into the Phase II robot. Fiber optic communications with remote video processors have been installed. Software for identifying a target is being developed.

Schedule:
Phase II demonstration: May 90
Target identification software: July 90
Preliminary Phase III design: Sep 90

190-82

Title:
Orbiter and Space Station Control Station Breadboard

Description:
Provide breadboards for the FTS Control Workstations for the Orbiter and Space Station. The breadboards will be evaluated at JSC. The workstations will interface with the FTS operator and provide hardware and software interfaces with the FTS HLCM for the respective vehicles.

Program: Space Station Date: Jan 89
NASA Headquarters Program Code:
UPN/PWC: 486-24

Point of Contact: Duane Johnson Telephone: 483-1519
Division: ER - Automation and Robotics
Branch: Robotic Systems Development
Section: Teleoperated Robots

State: Active

Categories Describing the Work of this Project:

1.4 Human-machine interface
2.1 Supporting software and hardware

1.4-1 Controls
1.4-2 Displays
2.1-1 Accommodation for automation & robotics in design

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
5 Component or breadboard tested in the relevant environment

Current Status:
The Orbiter breadboard has been completed.
The Space Station breadboard is in work.

Schedule:
Breadboard -- FTS workstation for the Orbiter completed: Feb 89
Breadboard -- FTS workstation for the Space Station completed: Apr 90

190-116

Title:
An Intelligent Mobile Research Robot

Description:
Develop an intelligent mobile robot that is reconfigurable and useful in research on evolutionary robotics.

Program: Advanced Programs

Date: Mar 90

Point of Contact: John Chladek
Telephone: 483-1528
Division: ER - Automation and Robotic
Branch: Robotic Systems Development
Section: Teleoperated Robots

State: discontinued

Categories Describing the Work of this Project:

2.4 Robotic and telerobotic systems
2.3 Knowledge based or expert systems
1.1 Knowledge
1.2 Sensing

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
3 Conceptual design tested

Current Status:
Initial development and construction is in progress: Initial development is well underway in laser and vision sensing,knowledge-based understanding of images, navigation and avoidance of obstacles, and Lisp modes. JSC is no longer participating in this project; it continues at Rice University.

Schedule:

190-122

Title:
Hardware-in-the-Loop Simulation

Description:
In a simulation, with dynamics, of a multi-link manipulation, an electrical motor is substituted for the motor model in one joint of the manipulator. The simulation computes the dynamic loading on the servo motor and uses it to drive a second motor, termed the load motor, that is coupled to the servo motor to find the actual dynamic loading.

Program: Advanced Programs

Date: Jan 90

Point of Contact: John Chladek
Telephone: 483-1528
Division: ER - Automation and Robotics
Branch: Robotic Systems Development
Section: Teleoperated Robots

State: low level

Categories Describing the Work of this Project:

1.3 Actuation and manipulation

1.3-5 Control technology

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
5 Component or breadboard tested in the relevant environment

Current Status:
The initial breadboard has been tested and the concept proven. A new breadboard is being developed.

Schedule:
The initial task, with low quality components, has been completed. A task with higher quality components, including a servo motor which has characteristics similar to an RMS servo joint motor, is in work. A torque sensor and a multiprocessing hardware system will be included.

190-129

Title:
Override Demonstration

Description:
Project Develop an intelligent agent to assist in overriding of automated functions. The communication and tracking test bed will be used in defining the needs for such a system. A prototype of the intelligent agent override will be developed and integrated with the Operations Management System testbed.

Program: Space Station

Date: Jan 90

Point of Contact: Ginger Pack

Telephone: 483-1515

Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Advanced Automation

State: discontinued

Categories Describing the Work of this Project:

2.1 Supporting software and hardware

2.1-2 Distributed systems
2.1-3 Fault-tolerant architecture
2.1-4 Management of resources

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Current Status:
Requirements are being defined.

Schedule:
Definition of requirements: Jan 89
First prototype: Apr 89

190-131

Title:
Helmet Mounted Display System

Description:
Develop and test a prototype display system. A pair of monitors mounted in a helmet will provide a true 3-dimensional visual representation of the window scenes, and a projection of the visual telepresence into the simulated environment.

Program: Advanced Programs

Date: June 89

Point of Contact: Peter Galicki
Telephone: 483-8086
Division: ER - Automation and Robotics
Branch: Robotic Systems Evaluation
Section: Robotic Applications Laboratories

State: Active

Categories Describing the Work of this Project:

1.4 Human-machine interface

1.4-2 Displays

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
8 Full operational capability (incorporated in production design)

Current Status:
Planning has been completed for upgrading to solid-surface graphics and for using wireframe graphics with multiple helmets.

Schedule:
Prototype tested: Sep 86
Full operational capability: Mar 87
Capability for high fidelity wireframe graphics: May 88
Capability for solid-surface graphics: un 90
Capability for wireframe graphics for two helmets: Jun 90
Multiple channel solid-surface/wireframe graphics: Jun 92

190-132

Title:
Advanced Graphics Laboratory Systems Development

Description:
Develop an independent smart front end for a graphics system. The modular system will be transportable between graphics systems, and will allow expansion to accommodate future hardware. It will eliminate long training times and improve the productivity of an engineer using a graphics system.

Program: Advanced Programs

Date: Jan 90

Point of Contact: Peter Galicki
Telephone: 483-8086
Division: ER - Automation and Robotics
Branch: Robotic Systems Evaluation
Section: Robotic Applications Laboratories

State: completed

Categories Describing the Work of this Project:

1.4 Human-machine interface

1.4-6 Interfaces to knowledge based or expert systems

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
8 Full operational capability (incorporated in production design)

Current Status:
Software and hardware have been completed.

Schedule:
Contract started: Mar 85
Preliminary design completed: Dec 85
First prototype completed: Apr 86
First prototype GTI completed: Aug 87
First prototype IRIS completed: Jul 88
Final software and hardware completed: Sep 88

190-133

Title:
Enhancement of Simulation/Animation Graphics System

Description:
Develop the next generation graphics system. A graphics engine using multiple CPUs and smart software will provide for animation and easy manipulation of data and objects in the display.

Program: Advanced Programs

Date: Jan 90

Point of Contact: Peter Galicki

Telephone: 483-8086

Division: ER - Automation and Robotics
Branch: Robotic Systems Evaluation
Section: Robotic Applications Laboratories

State: completed

Categories Describing the Work of this Project:

1.4 Human-machine interface

1.4-1 Controls
1.4-2 Displays

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
8 Full operational capability (incorporated in production design)

Current Status:
Software and hardware have been completed.

Schedule:
Contract started: Apr 86
Hardware prototype for a single processor completed: Aug 87
Hardware prototype for a dual processor completed: Jan 88
Software prototype completed: Mar 88
Final software and hardware completed: Jul 88

190-135

Title:
Mission Evaluation Room Advanced Automation Project (MAAP)

Description:
A coordinated effort of the Engineering and Mission Operations. Directorates will introduce sophisticated techniques for automation into ground control of the Shuttle. The MAAP, interfacing with the INCO expert system, will assist and advise the engineers. It will track changes in system data, detect faults, and generate graphical displays of information needed by engineers.

Program: Shuttle

Date: Mar 90

Point of Contact: Ginger Pack

Telephone: 483-1515

Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Advanced Automation

State: Active

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems

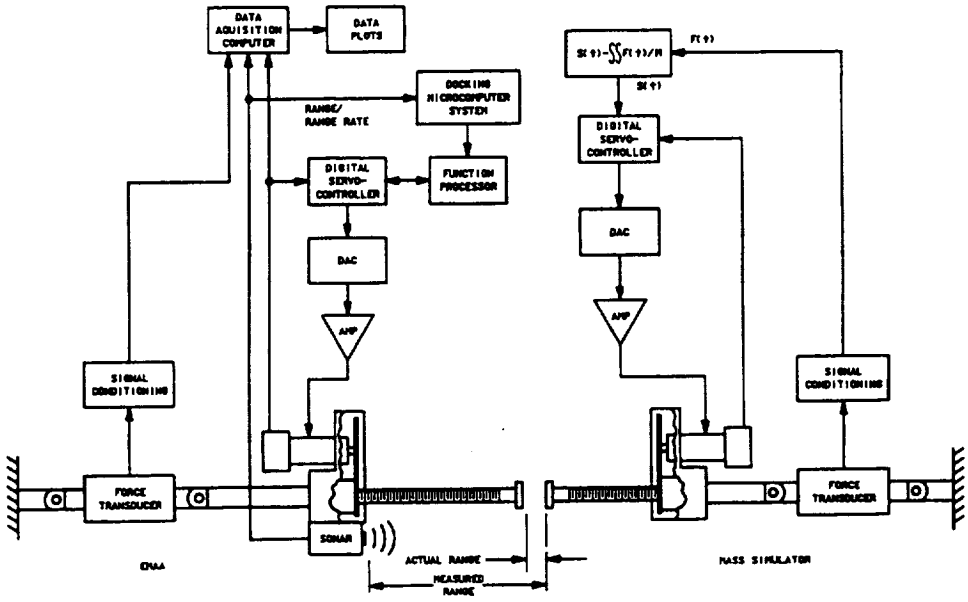
2.3-8 Management of faults
2.3-9 Monitoring

Funded: no

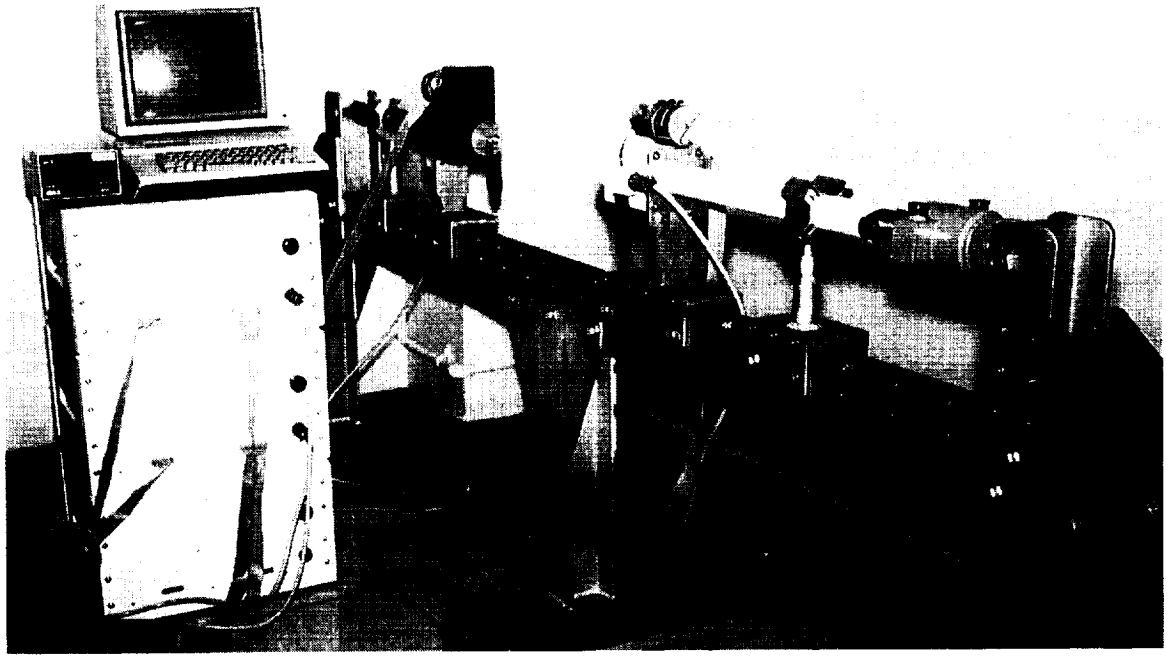
Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Current Status:
The concept has been documented and requirements are being defined.
Delivery of hardware is expected in mid-September, 1989.

Schedule:
Concept document and hardware installation: September 1989
Requirements document; demonstration during the flight of STS-34: Oct 89
Development of phase I software completed and demonstration during the flight of STS-32: December 1989
Development of phase II software completed and Demonstration during the flight of STS-31: March 1990



EMAA Testbed



190-136 Smart electromechanical attenuator/actuator for SS docking/berthing.

190-136

Title:
Smart Electromechanical Attenuator/Actuator for SS Docking/Berthing

Description:
Develop a smart electromechanical attenuator/actuator (EMAA) to support the RTOP on Construction Equipment/Soft Docking Technology. The EMAA will use a servo control loop to provide the motion for the soft capture and attenuation of the energy of a moving mass such as an orbital maneuvering vehicle (OMV). The concept of using six or eight EMAAs in a docking/berthing ring configuration will be demonstrated.

Program: Space Station
UPN/PWC: 482-53-8900
Date: Sep 89

Point of Contact: LeBarian Stokes
Division: ER - Automation and Robotics
Branch: Robotic Systems Evaluation
Section: Robotic Applications Laboratories
Telephone: 483-8965

State: discontinued

Categories Describing the Work of this Project:

1.3 Actuation and manipulation
2.1 Supporting software and hardware
2.2 System design and integration
2.3 Knowledge based or expert systems

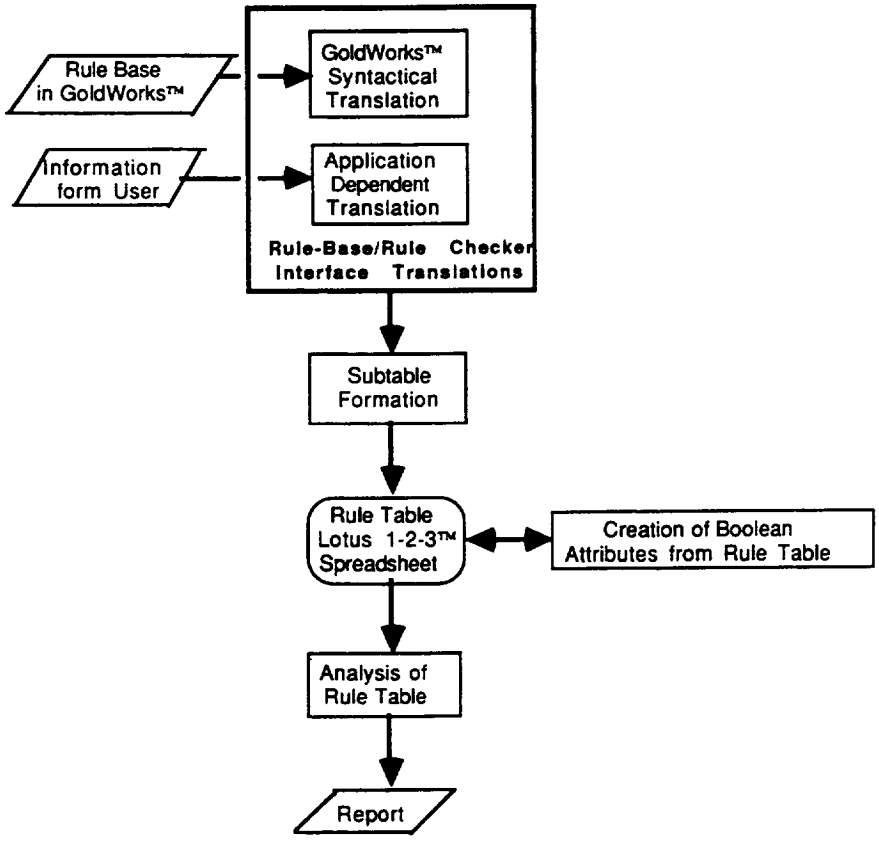
1.3-1 Actuation in expert systems
1.3-4 Compliance
1.3-5 Control technology
2.1-1 Accommodation for automation & robotics in design
2.2-2 Aids for design
2.3-3 Distributed expert systems

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
3 Conceptual design tested

Current Status:
A control system has been developed for a configuration with six or eight EMAAs in a docking ring. Simulation and testing of the control system is continuing. Hardware has been procured and is being integrated with the control system.

Schedule:
Test the control system for the docking ring configuration with eight EMAAs using prototype hardware: Sep 88



190-138 Verification and validation of rule–based systems.

190-138

Title:
Verification and Validation of Rule Based Systems

Description:
A study of verification and validation of rule based systems is currently being conducted. The end product will be a program to test the knowledge base of such a system for completeness, ambiguity, and conflict.

Program: Advanced Programs

Date: Feb 90

Point of Contact: Jodi Seaborn
Telephone: 483-2059
Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Automated Robotics

State: in 190-84

Categories Describing the Work of this Project:

2.2 System design and integration

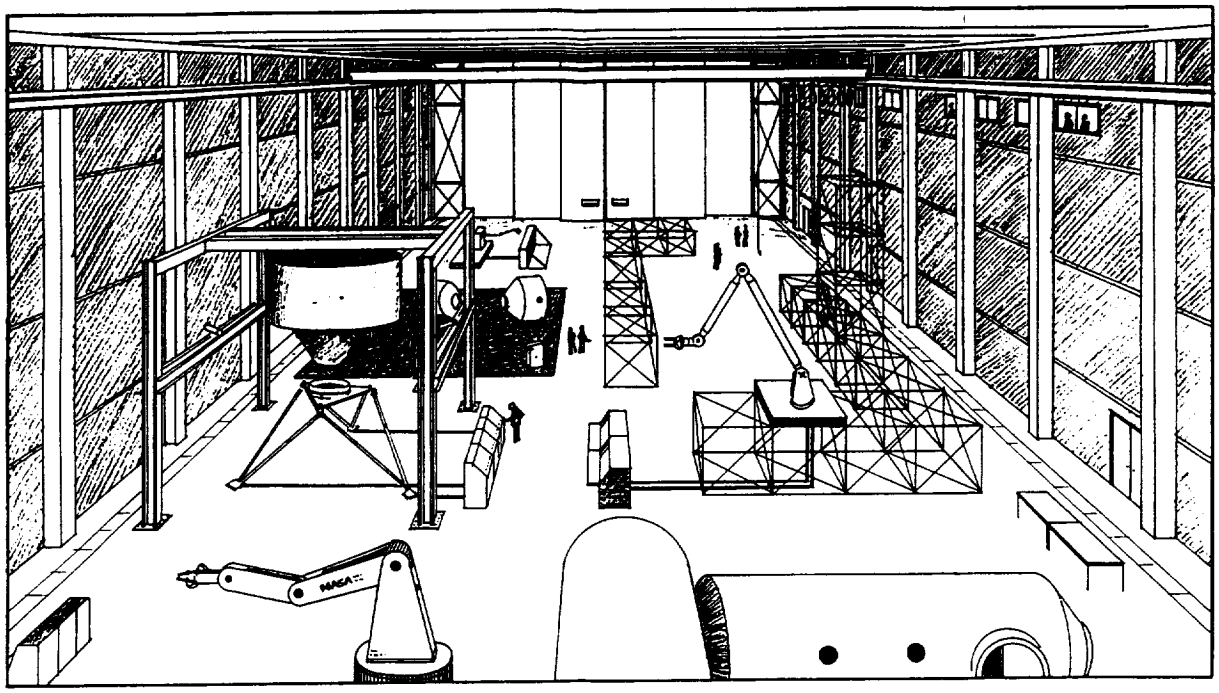
2.2-10 Validation and verification

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
2 Conceptual design formulated

Current Status:
Included in CONFIG, 190-84.

Schedule:
Included in CONFIG, 190-84.



190-139 Structural assembly, berthing, and manufacturing support.

190-139

Title:
Structural Assembly, Berthing, and Manufacturing Support

Description:
Construct a facility for verification testing. Verify the reliability and efficiency of techniques and automated mechanisms or systems for performing complex tasks in space: assembly of a Space Station on orbit, attachment of components and modules to the structure, installation of utilities, docking and berthing of an Orbiter to the station, and manufacturing in space.

Program: Space Station

Date: Apr 90

Point of Contact: Walter Guy

Telephone: 483-4931

Division: ER - Automation and Robotics

State: inactive

Categories Describing the Work of this Project:

2.4 Robotic and telerobotic systems
1.3 Actuation and manipulation
2.1 Supporting software and hardware
1.4 Human-machine interface

2.4-1 Assembly
1.4-2 Displays
2.4-6 Servicing and repair
1.3-1 Actuation in expert systems
2.1-1 Accommodation for automation & robotics in design
1.4-6 Interfaces to knowledge based or expert systems

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
Level not given

Current Status:
It has been proposed that construction of facilities for this project begin in FY89. Definition of the assembly process is ongoing. The robotics part of the project is inactive.

Schedule:
Start defining the process of assembly of the Space Station: Dec 87
Construction of the testing facility completed: Dec 89
Activation of the completed facility: Jun 90

190-22

Title:
Functional Area Manager for Design Knowledge Capture

Description:
Monitor, coordinate, and direct work in Design Knowledge Capture (DKC) at JSC and within Work Package 2. Provide guidance to the DKC team at McDonnel-Douglas, provide assistance for line organizations at JSC dealing with design knowledge, coordinate with the Level III projects office, and maintain communication with Level II Space Station people working Design Knowledge Capture.

Program: Space Station Date: Jan 90
NASA Headquarters Program Code:S

Point of Contact: K. Crouse Telephone: 483-2040
Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Advanced Automation

State: in 190-53

Categories Describing the Work of this Project:

1.1 Knowledge
2.2 System design and integration

1.1-1 Acquisition of knowledge
1.1-12 Representation and reasoning
2.2-2 Aids for design
2.2-1 Aids for documentation

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
1 Basic principle observed or reported

Current Status:
Included in Design Knowledge Capture.

Schedule:
Incorporated into Design Knowledge Capture.

190-34

Title:
Collision-Free Path Planning/Robotics Software Test Bed Architecture

Description:
Develop dynamic models for planning collision-free paths for robot manipulators. Develop a conceptual framework for purchases of hardware and software for the NASA/MPAD test bed for software for robotics.

Program: Advanced Programs
UPN/PWC: NCC 9-16

Date: Dec 89

Point of Contact: Les Quiocho
Division: ER - Automation and Robotics
Branch: Robotic Systems Evaluation
Section: Robotic Applications Laboratories

Telephone: 483-8633

State: Active

Categories Describing the Work of this Project:

1.3 Actuation and manipulation
2.1 Supporting software and hardware

1.3-3 Collision avoidance
2.1-2 Distributed systems

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Current Status:
A series of possible architectures for the Robotics Software Testbed are being examined. A time-scale approach for the case of a dynamic environment is being studied. Funding ran out in December 87. The preliminary model for avoiding collisions in a simple static environment has been completed. Work continues at a low level to upgrade the model to the 3-dimensional regime.

Schedule:
Initiate the contract: Jan 87
Phases 1 and 2 of the architecture study completed: May 87
Algorithm for collision avoidance completed: Sep 87
Development of the architecture completed: Sep 88

190-36

Title:
Simulation of Robotics Space Operations

Description:
Coordinate the various robotics activities and include them in a unified simulation of a mission for servicing satellites. The simulation of orbital operations (OOS: Orbital Operations Simulation) will be updated, and the Rendezvous and Navigation Expert System (RENEX) will be modified. The simulations will be integrated into an end-to-end simulation, using graphics, of a satellite servicing mission.

Program: Advanced Programs

Date: Dec 89

Point of Contact: Les Quiocho

Telephone: 483-8633

Division: ER - Automation and Robotics
Branch: Robotic Systems Evaluation
Section: Robotic Applications Laboratories

State: in 190-41

Categories Describing the Work of this Project:

1.1 Knowledge

1.1-14 Simulation

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Current Status:
This project is included in 190-41.

Schedule:
Included in 190-41.

190-48

Title:
Robotic Arms for Manipulating Equipment During Thermal Vacuum Tests

Description:
Investigate the use of robotic arms to enhance the fidelity of tests in the thermal vacuum chambers at JSC. The arms must allow tools and equipment for EVA and assembly to be manipulated and actuated in the extremes of temperature and pressure in the thermal vacuum tests that simulate conditions in space.

Program: Space Station
Task no.: 7

Date: Jan 90

Point of Contact: Cliff Hess
Division: ER - Automation and Robotics
Branch: Robotic Systems Development
Section: Autonomous Robots

Telephone: 483-9142

State: inactive

Categories Describing the Work of this Project:

2.4 Robotic and telerobotic systems

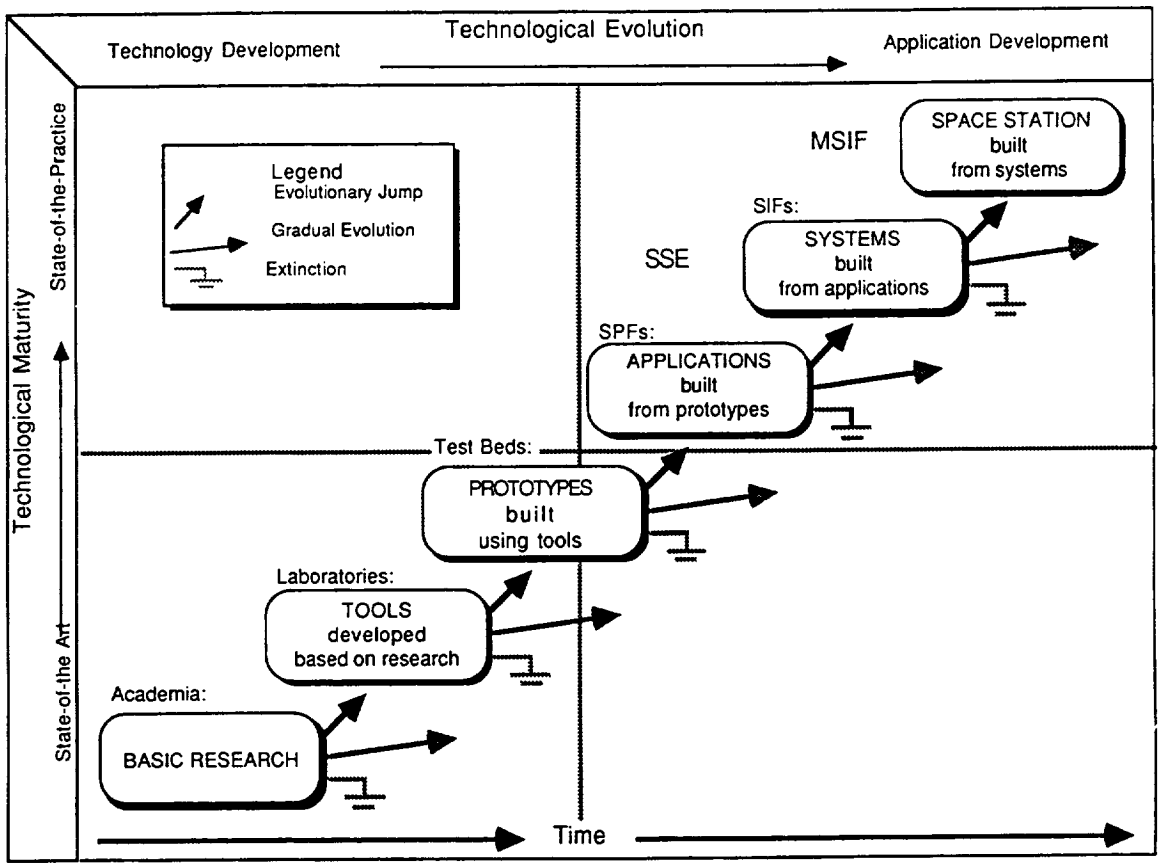
2.4-2 Automatic inspection
2.4-5 Handling of parts
2.4-6 Servicing and repair

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Current Status:
Two 6-DOF arms, RM-10, from Remote Technology Corporation, Oak Ridge, TN, have been received and checked out. Methods have been developed for controlling the arms, by computer, independently of the master exoskeleton. The arms are being used to support the EVA Retriever project. This project is inactive.

Schedule:
The project is inactive.



190-52 Definition of advanced automation testbed requirements.

190-52

Title:
Definition of Advanced Automation Testbed Requirements

Description:
Define the evolutionary paths for testbeds and facilities for the Space Station Freedom Program (SSFP) including the Software Support Environment (SSE) and Multi-System Integrated Facilities (MSIF), to support the development of technology for advanced automation for use on the evolutionary space station and in future space missions beyond our planet.

Program: Space Station

Date: Jan 90

Point of Contact: K. Crouse

Telephone: 483-2040

Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Advanced Automation

State: completed

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems

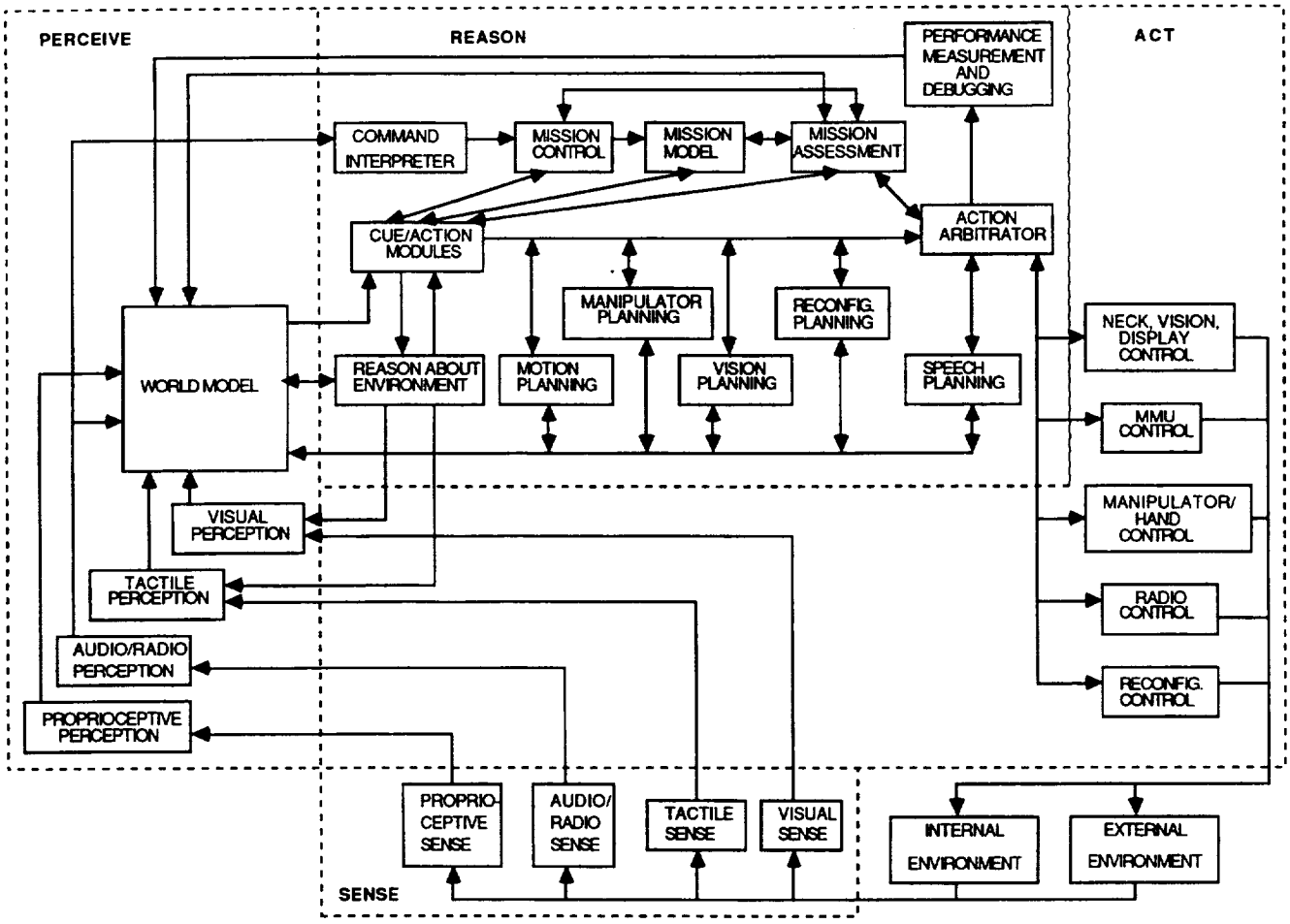
2.3-2 Data base management
2.3-3 Distributed expert systems
2.3-5 Executives for expert systems
2.3-6 Hybrid expert systems
2.3-7 Interacting expert systems

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
2 Conceptual design formulated

Current Status:
This project has been completed.

Schedule:
Update review of facilities and capabilities of SSFP for development of advanced automation: Sep 89
Concepts for evolution of testbeds and facilities for SSFP: Sep 89
Plans for SSE: Sep 89
Definition of requirements for a transition testbed: Sep 89
The task has been completed.



190-56 EVA retriever central software.

190-56

Title:
EVA Retriever Central Software

Description:
Develop intelligent system software for a ground based test bed for retrieval of crew and equipment separated from a spacecraft. Visual perception, planning and reasoning modules, command, control and communications, action arbitrator, etc. will be included. In Phase II demonstrations on the PABF fixed obstacles will be avoided while a fixed astronaut or tools are retrieved and handed off to the crew.

Program: Center Director's Discretionary Fund
NASA Headquarters Program Code: MD
UPN/PWC: 307-51-6720

Date: January 1990

Point of Contact: Jon D. Erickson
Division: ER - Automation and Robotics

Telephone: 483-1508

State: Active

Categories Describing the Work of this Project:

2.4 Robotic and telerobotic systems
1.1 Knowledge

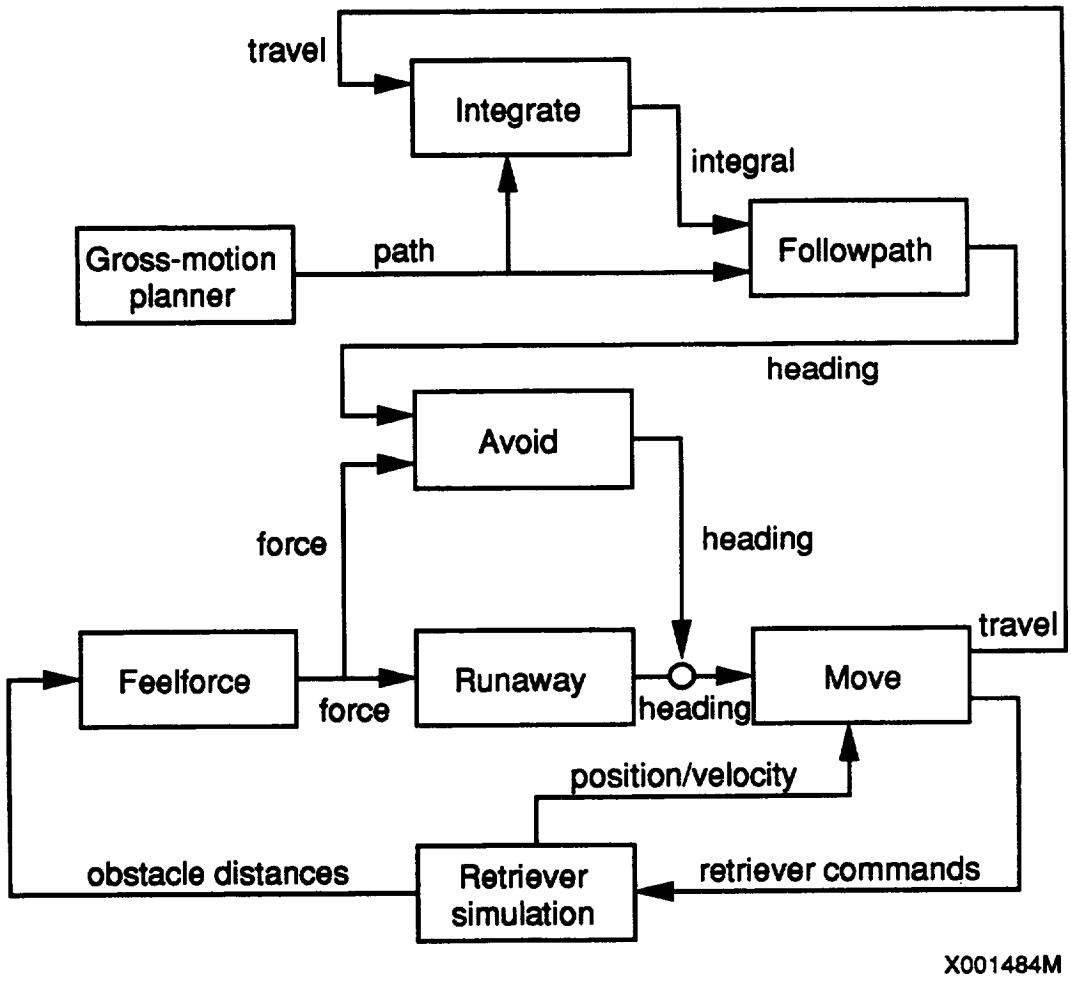
2.4-7 Retrieval and rescue
1.1-1 Acquisition of knowledge
1.1-2 Control methods
1.1-8 Perceptual reasoning
1.1-9 Planning
1.1-11 Recognition of objects

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
5 Component or breadboard tested in the relevant environment

Current Status:
Integration testing for avoidance of fixed obstacles while retrieving a fixed astronaut or tools.

Schedule:
Phase II demonstrations on the Precision Air Bearing Floor: March 89
Phase III Software design: Sep 90
Phase III simulation: Mar 90



190-60 Control architecture for autonomous robotics.

190-60

Title:
Control Architecture for Autonomous Robotics

Description:
Develop and evaluate various architectures for control of autonomous robotics that allow for upgrading the technology and advancement toward more intelligent "actions." The end products will be architectures that have shown potential for use in advanced robotics.

Program: Advanced Programs

Date: Jan 90

Point of Contact: Mike Heidt
Telephone: 483-2048
Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Automated Robotics

State: discontinued

Categories Describing the Work of this Project:

2.1 Supporting software and hardware
1.4 Human-machine interface

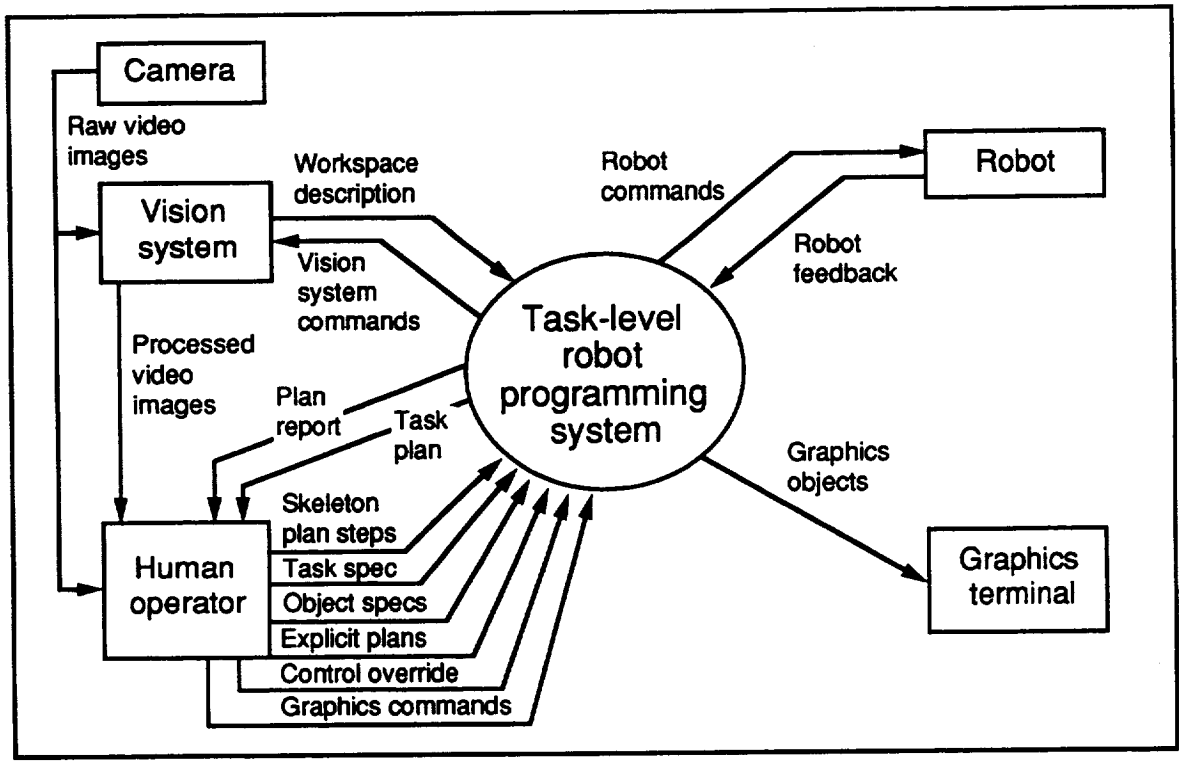
2.1-1 Accommodation for automation & robotics in design
2.1-6 Specialized architecture for artificial intelligence
1.4-4 Fusion of sensors
1.4-7 Management of user interfaces

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Current Status:
A vision system based on an IBM PC, A Symbolics machine, and a Microbot arm have been integrated into a system. Software to provide for the performance of various tasks is being written. Plans are being made for moving the visions based system to the EF2 Puma arm. The control architecture and CAD data base will be put on an IRIS work station. This project has been discontinued.

Schedule:
Build a series of rapid prototypes for use in investigating the use of data bases for computer aided design (CAD) as part of a control architecture. This project has been discontinued.



190-61 Task level robot programming for EVA retriever simulation.

190-61

Title:
Task Level Robot Programming for EVA Retriever Simulation

Description:
Use Deneb software for simulating robotics on the IRIS workstation to develop a simulator for the EVA Retriever, concentrating on applications at zero-g.

Program: EVA Retriever

Date: Jan 90

Point of Contact: Mike Heidt
Telephone: 483-2048
Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Automated Robotics

State: discontinued

Categories Describing the Work of this Project:

2.2 System design and integration
2.4 Robotic and telerobotic systems

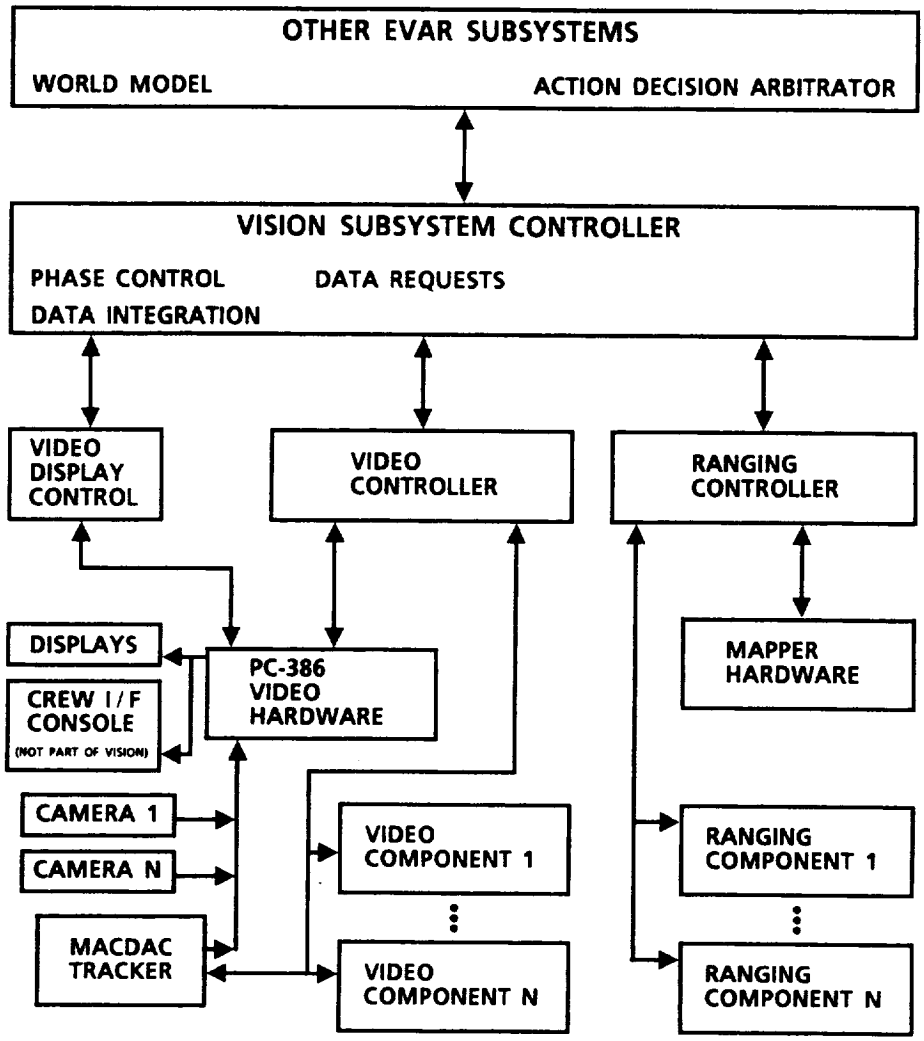
2.2-7 Environments for automation
2.4-7 Retrieval and rescue

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
3 Conceptual design tested

Current Status:
In the planning stage. Hardware is on order or in place. Activity proceeds at a low level.

Schedule:
Preliminary demonstration: 3rd quarter of FY90



190-62 Vision for the EVA retriever.

190-62

Title:
Vision for the EVA Retriever

Description:
A vision system that gets data from video cameras and a 3D laser scanner will provide information for the EVA Retriever on obstacles, targets, and locations for hands to grasp targets. In Phase II retrieval of an unknown (not modeled) stationary target in a field of stationary obstacles will be demonstrated. In Phase III there will be moving obstacles and targets.

Program: Director's Discretionary Fund Date: Jan 90

Point of Contact: Robert Goode Telephone: 483-2047
Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Automated Robotics

State: Active

Categories Describing the Work of this Project:

2.4 Robotic and telerobotic systems
1.2 Sensing

2.4-3 Computer vision systems
2.4-7 Retrieval and rescue
1.2-14 Visual and optical

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Current Status:
The Phase II demonstration software is being implemented and integrated into the EVA Retriever.

Schedule:
Phase II Demonstration: Spring 1989
Phase III Demonstration: Spring 1990

190-63

Title:
Vision for Grasping for EVA Retriever

Description:
Design and develop algorithms for computer vision to support closed-loop grasping by the EVA Retriever. Integrate close-loop software with planning and control modules of the EVA Retriever.

Program: Space Station

Date: Jan 90

Point of Contact: K. Crouse

Telephone: 483-2040

Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Advanced Automation

State: discontinued

Categories Describing the Work of this Project:

2.1 Supporting software and hardware
2.2 System design and integration
2.3 Knowledge based or expert systems
1.1 Knowledge

2.1-1 Accommodation for automation & robotics in design
2.2-6 Automation of engineering
1.1-4 Diagnosis
1.1-7 Monitoring
1.1-13 Search techniques

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Current Status:
This project has been discontinued.

Schedule:

190-67

Title:
Algorithm for Using Multiple Manipulator Arms to Control a Payload

Description:
Define algorithms for control of the trajectory of a payload, in three dimensions, using two coordinated manipulator arms with a capability for changing the distance between the bases. Define the computer for controlling the arms and the method of teleoperated and robotic control. Use a simulator to assess the need for adding a joint to the arms and the effect of forces and moments and preprogrammed automatic sequences.

Program: SBIR Phase II
UPN/PWC: 324-01-EA-04
Task no.: 1

Date: Jan 90

Point of Contact: Gerald J. Reuter
Division: ER - Automation and Robotics
Branch: Robotic Systems Evaluation
Section: Robotic Utilization

Telephone: 483-1520

State: completed

Categories Describing the Work of this Project:

1.3 Actuation and manipulation

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
3 Conceptual design tested

Current Status:
The project has been completed.

Schedule:
The project was completed in December 1989.

190-71

Title:
Procedural Reasoning System

Description:
This is a joint project with Ames Research Center. It will extend a project funded by OAST that uses procedural reasoning to diagnose and control subsystems of the Shuttle Orbiter. An expert system will be developed to perform fault diagnosis of the Shuttle Remote Manipulator System. It will be demonstrated in operations with the System Engineering Simulator (SES).

Program: Space Station Transition Definition
NASA Headquarters Program Code: ST
UPN/PWC: 488-50

Date: Jan 90

Point of Contact: H. K. Hiers
Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Advanced Automation

Telephone: 483-2036

State: discontinued

Categories Describing the Work of this Project:

1.1 Knowledge
2.3 Knowledge based or expert systems
2.2 System design and integration
1.4 Human-machine interface

1.1-12 Representation and reasoning
2.3-9 Monitoring
2.2-9 Shells for knowledge based or expert systems
1.4-1 Controls
1.4-2 Displays
1.4-6 Interfaces to knowledge based or expert systems

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Current Status:
Preparations are being made for a final demonstration.

Schedule:
Project plan completed: Mar 89
Definition of requirements completed: Sep 89
Demonstration of the prototype: Jan 90

190-83

Title:
Model and Simulation for FTS Control Station Testbed and Brassboard

Description:
Support development of the FTS workstation by providing kinematic and graphic models of the FTS on the IRIS workstation. The model will provide both a visual scene and hardwired feedback to the FTS workstation breadboards.

Program: Space Station
UPN/PWC: 486-25

Date: Jan 90

Point of Contact: Sue Burns
Division: ER - Automation and Robotics
Branch: Robotic Systems Development
Section: Teleoperated Robots

Telephone: 483-1541

State: low level

Categories Describing the Work of this Project:

1.4 Human-machine interface

1.4-1 Controls
1.4-2 Displays

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
Level not given

Current Status:
The FTS tinman has been implemented.
The Martin Marietta FTS is in work.

Schedule:
FTS model: Completed
Update of the FTS model: Oct 89
Update of the FTS model: Feb 90

190-93

Title:
Black Board Architecture Shell

Description:
Implement a software shell for rapid prototyping of expert systems.

Implement the above tool for multitasking and distributed systems.

Program: Advanced Programs Date: Jan 90

Point of Contact: Bryan Basham Telephone: 483-2065
Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Advanced Automation

State: low level

Categories Describing the Work of this Project:

2.1 Supporting software and hardware

2.1-6 Specialized architecture for artificial intelligence
2.1-2 Distributed systems

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Current Status:
The initial shell, called Chalk, has been developed and tested.

Schedule:
No schedule currently.

190-94

Title:
Electrolysis Fault Diagnosis Expert System

Description:
Develop an expert system to demonstrate the capability for diagnosis of failures in electrolysis units in the propulsion system. The electrolysis unit uses water and produces H2 and O2 for use as possible propellant for the space station.

Program: Space Station Advanced Automation Date: Jan 90

Point of Contact: Jeff Kowing Telephone: 483-2064
Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Advanced Automation

State: Active

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems
1.1 Knowledge
1.4 Human-machine interface

2.3-8 Management of faults
1.1-4 Diagnosis
1.1-1 Acquisition of knowledge
1.4-6 Interfaces to knowledge based or expert systems

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
1 Basic principle observed or reported

Current Status:
The knowledge acquisition phase is continuing.

Schedule:

190-95

Title:
Connected Autonomous Neural Sight-Arm System (CANSAS)

Description:
The intent of the CANSAS project is to determine the feasibility of using the technology of neural networks in the design and development of a hand-eye robotic system that enables a manipulator to use data from visual sensors in grasping an object.

Program: EVA Retriever

Date: Jan 90

Point of Contact: Jeff Kowing

Telephone: 483-2064

Division: ER - Automation and Robotics
Branch: Intelligent Systems
Section: Advanced Automation

State: Active

Categories Describing the Work of this Project:

2.4 Robotic and telerobotic systems
1.1 Knowledge
2.1 Supporting software and hardware

2.4-3 Computer vision systems
1.1-6 Learning
1.1-8 Perceptual reasoning
1.1-11 Recognition of objects
2.1-6 Specialized architecture for artificial intelligence

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
1 Basic principle observed or reported

Current Status:
A 2-D vision recognition system is being implemented.

Schedule:

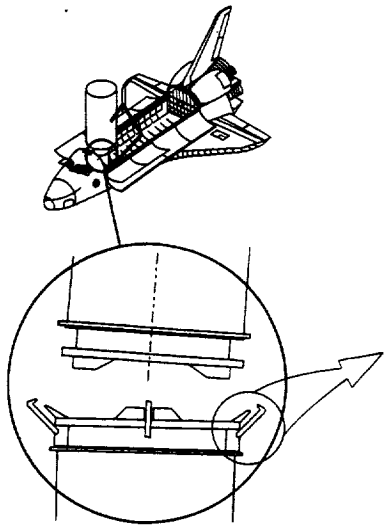
PROJECTS REPORTED BY ES - STRUCTURES AND MECHANICS DIVISION

Category:	Projects
1.3 Actuation and manipulation	2

Level of Technological Readiness at the End of FY90	Projects
3 Conceptual Design Tested	1
4 Critical Function or Characteristic Demonstrated	1

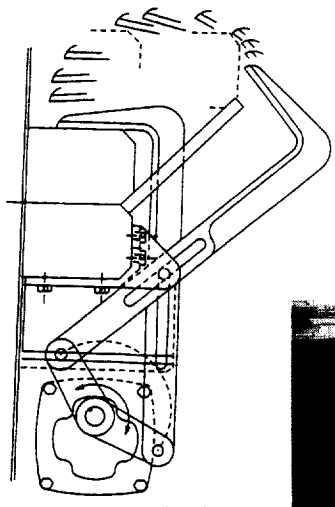
Number of Projects 2

Title	Number	Page
Long Reach Latch Development	190-118	165
Payload Installation and Deployment Aid (PIDA)	190-125	167

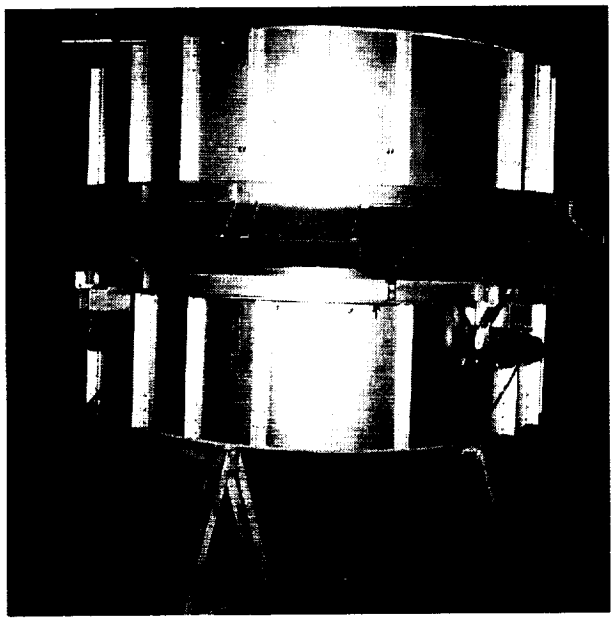


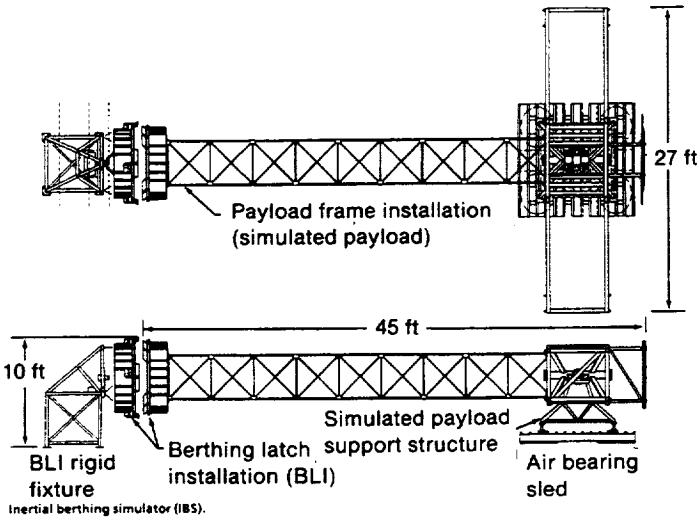
Berthing interfaces

Long reach berthing latch system.



Berthing latch mechanism





Inertial berthing simulator (IBS).

190-118 Long reach latch development.

190-118

Title:
Long Reach Latch Development

Description:
Develop a constant velocity system using optical feedback to synchronize the four latches in the system for berthing a space vehicle to the Space Station. The androgynous (both sides identical) system consists of an 80-inch diameter ring and latches that can reach to 4 inches to pull the two vehicles together. Test the system on the air bearing floor using a 30,000 pound inertial berthing simulator.

Program: Space Station Advanced Development
UPN/PWC: 481-30-29-02

Date: Mar 90

Point of Contact: P. Fantasia
Telephone: 483-8967
Division: ES - Structures and Mechanics
Branch: Mechanical Design and Analysis
Section: Design

State: inactive

Categories Describing the Work of this Project:

1.3 Actuation and manipulation
1.2 Sensing
1.4 Human-machine interface
2.3 Knowledge based or expert systems

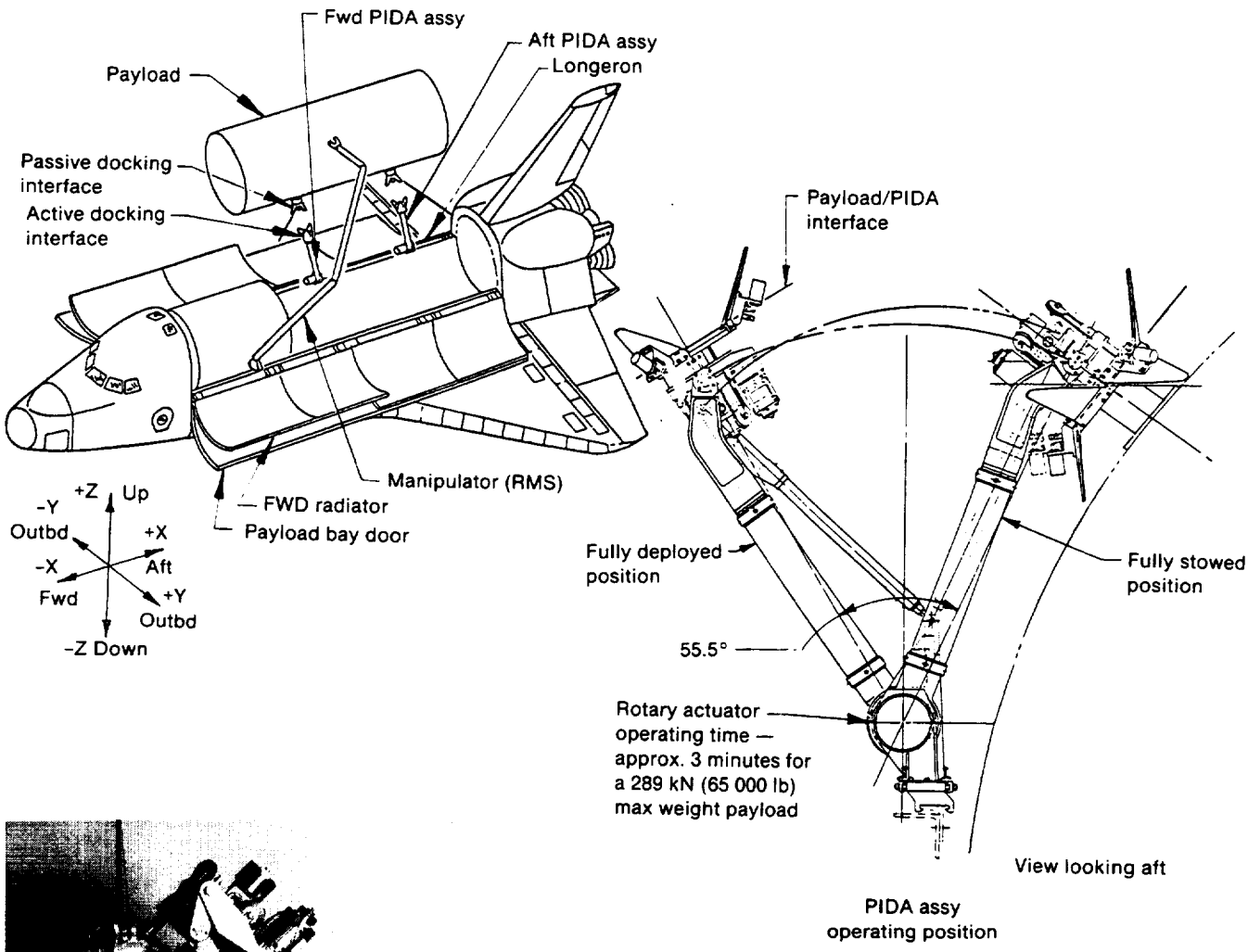
1.3-5 Control technology
1.3-1 Actuation in expert systems
1.2-11 Range and rate
1.4-5 Input mechanisms
2.3-15 Retrieval and rescue

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
3 Conceptual design tested

Current Status:
The Phase I berthing mechanism has been assembled. Fabrication of the inertial berthing simulator is completed; the Phase I berthing mechanism has been tested. The system has been tested, but synchronization has not been tested.

Schedule:
Complete testing of the system with an analog motor: Oct 88
Final report completed (Part I): Dec 89
Complete testing with a motor controlled by computer: Apr 89



190-125 Payload installation and deployment aid (PIDA).

190-125

Title:
Payload Installation and Deployment Aid (PIDA)

Description:
Complete development and testing of prototype hardware for the Payload Installation and Deployment Aid (PIDA), a docking system used to deploy large diameter payloads from the cargo bay of the space shuttle. The hydraulic attenuation system will be replaced by a system with electromechanical attenuators and actuators to dampen the docking loads.

Program: Shuttle
UPN/PWC: 483-53-89-00

Date: Nov 88

Point of Contact: Guy King
Telephone: 483-8966
Division: ES - Structures and Mechanics
Branch: Mechanical Design and Analysis
Section: Design

State: low level

Categories Describing the Work of this Project:

1.3 Actuation and manipulation
1.4 Human-machine interface
2.1 Supporting software and hardware
2.4 Robotic and telerobotic systems

1.3-4 Compliance
1.3-9 Propelling mechanisms
1.3-10 Recovery from errors
1.4-2 Displays
2.1-3 Fault-tolerant architecture
2.4-5 Handling of parts

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Current Status:
The prototype of the Payload Installation and Deployment Aid is complete. Design of hardware for testing will be completed in February 1989.

Schedule:
Prototype hardware has been completed.
Test for structural integrity and proof-of-concept: May 90
Design the implementation of the electromechanical system: Dec 90
New hardware fabricated: June 91
Test the system: Oct 91
System ready for integration into the flight systems: Jan 93

This page intentionally left blank.

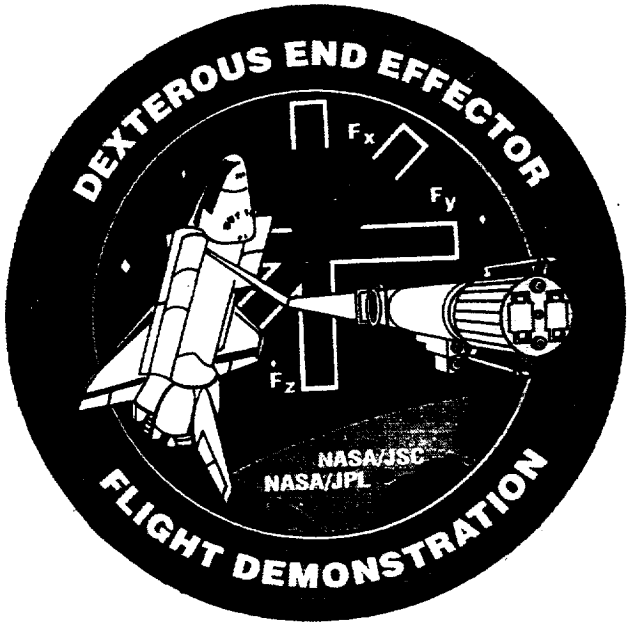
PROJECTS REPORTED BY IA - NEW INITIATIVES OFFICE

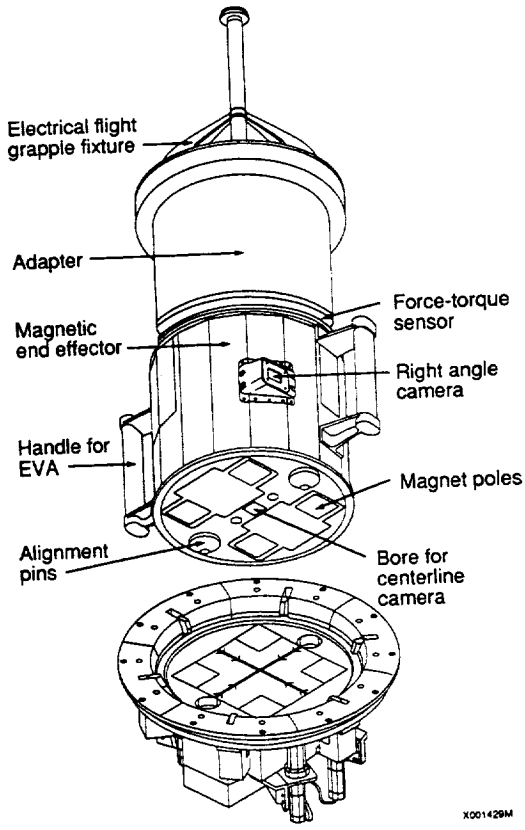
Category:	Projects
2.4 Robotic and Telerobotic Systems	2

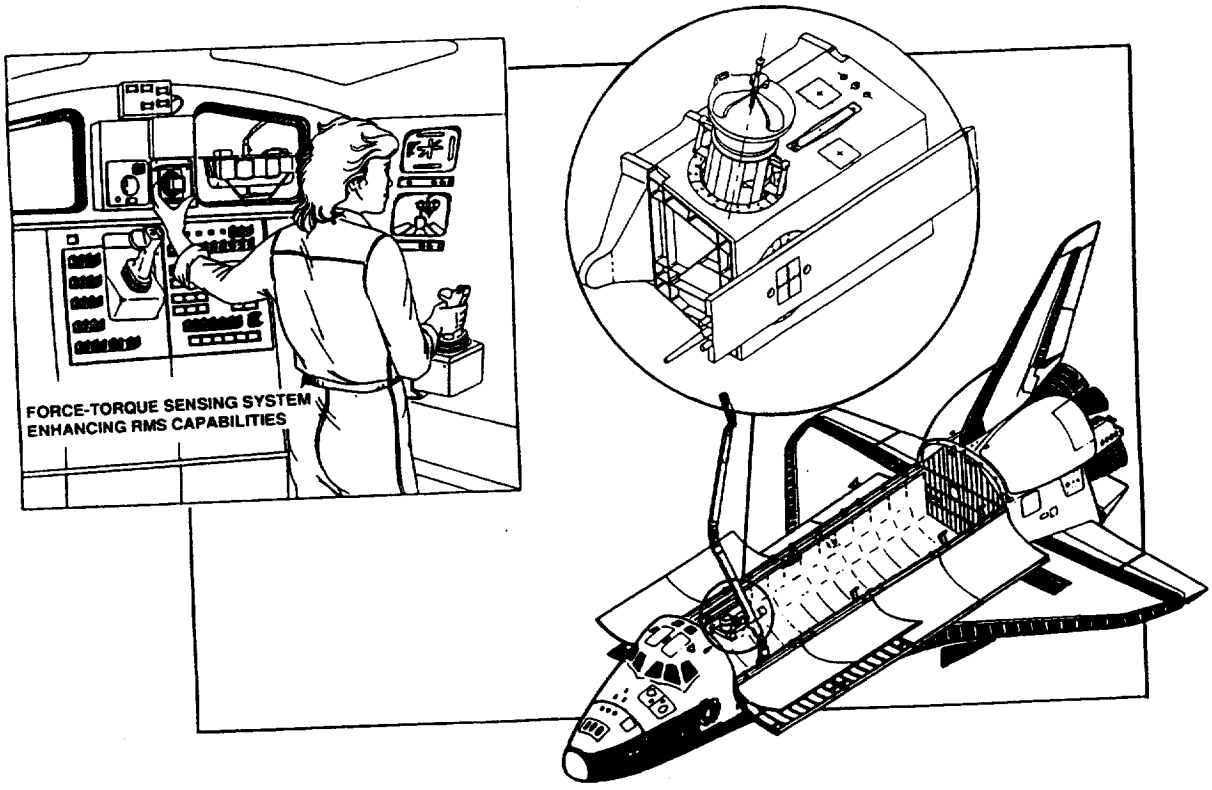
Level of Technological Readiness at the End of FY90	Projects
2 Conceptual Design Formulated	1
6 Prototype or Engineering Model Tested in the Relevant Environment	1

Number of Projects 2

Title	Number	Page
Demonstration of Magnetic Attachment Tool and Magnetic End Effector	190-26	173
Dexterous Manipulator Demonstration Flight Experiment	190-25	171







190-25 Dexterous manipulator demonstration flight experiment.

190-25

Title:
Dexterous Manipulator Demonstration Flight Experiment

Description:
Flight demonstration, on the Shuttle, of a magnetic end effector and a force and torque sensor mounted on the RMS on an Electrical Flight Grapple Fixture. Several tasks will require greater dexterity than is currently available with the Shuttle RMS. Demonstrate the capability of the FTS for graphical display of RMS torque to the operator. Construction, maintenance, and operational tasks will be simulated.

Program: Shuttle
Date: Jan 90
NASA Headquarters Program Code: MD, RC
UPN/PWC: 906-30-XX

Point of Contact: Leo G Monford
Telephone: 282-1809
Division: IA - New Initiatives Office
Branch: Space Servicing Systems Project Office

State: in use

Categories Describing the Work of this Project:

2.4 Robotic and telerobotic systems
1.2 Sensing
1.3 Actuation and manipulation
1.4 Human-machine interface

2.4-4 Construction
2.4-6 Servicing and repair
1.2-7 Force and torque
1.3-7 End effectors
1.3-8 Manipulators
1.4-3 Feedback of force and torque

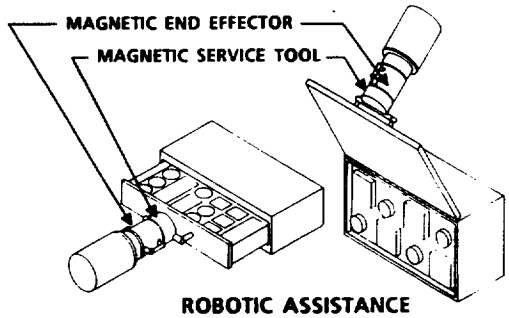
Funded: yes

Expected Level of Technology at the End of the Fiscal Year: 6 Prototype or engineering model tested in the relevant environment

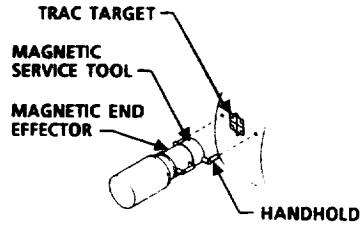
Performing Organizations	Name of Contact	Telephone
Jet Propulsion Laboratory	Joe Hanson	(818) 354-8148

Current Status:
The project is in the conceptual design phase.
Form 1628 has been approved by NASA Headquarters.

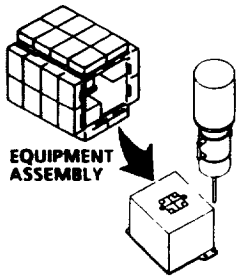
Schedule:
CDR: Sep 89
Flight Ready: Oct 90
Manifested for STS 56



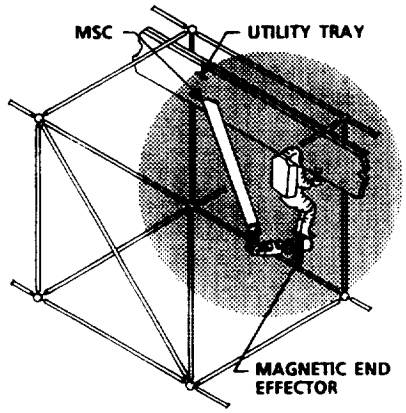
ROBOTIC ASSISTANCE
FOR EVA CREWPERSON
(EVA GLOVED HAND COMPATIBLE)
(TYPICAL TASK)



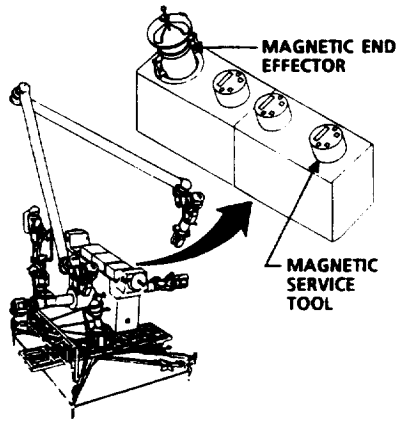
HANDHOLD INSTALLATION
AT MAINTENANCE OR
SERVICE LOCATION
(TYPICAL TASK)



REPLACEMENT OF
ORU OR MODULE
(TYPICAL TASK)



UTILITY TRAY MAINTENANCE



MAGNETIC END EFFECTOR AND
MAGNETIC SERVICE TOOL STOWAGE
(TYPICAL)

190-26 Demonstration of magnetic attachment tool and magnetic end effector.

190-26

Title:
Demonstration of Magnetic Attachment Tool and Magnetic End Effector

Description:
Develop advanced devices for magnetic attachment, including capabilities for transfer of data and power. Develop concepts for retention systems actuated by magnetic manipulators, hand-rails installed by manipulators, tools grappled magnetically, holding devices, and other systems to facilitate construction, maintenance, and operations in space.

Program: Space Station
NASA Headquarters Program Code: S
UPN/PWC: 472-46

Date: Jan 90

Point of Contact: Leo G. Monford
Division: IA - New Initiatives Office
Branch: Space Servicing Systems Project Office

Telephone: 282-1809

State: Active

Categories Describing the Work of this Project:

2.4 Robotic and telerobotic systems
1.2 Sensing
1.3 Actuation and manipulation
1.4 Human-machine interface

2.4-4 Construction
2.4-6 Servicing and repair
1.2-7 Force and torque
1.3-7 End effectors
1.3-8 Manipulators
1.4-3 Feedback of force and torque

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
2 Conceptual design formulated

Performing Organizations	Name of Contact	Telephone
Lockheed Engineering & Sciences Company	Ed Carter	(713) 333-6413

Current Status:
The conceptual designs are being formulated.

Schedule:
Conceptual Design: 1989
Development of the prototype: 1990
Flight demonstration: 1993-1995

This page intentionally left blank.

PROJECTS REPORTED BY IC - TECHNOLOGY AND COMMERCIAL PROJECTS OFFICE

Category:	Projects
2.4 Robotic and Telerobotic Systems	1

Level of Technological Readiness at the End of FY90	Projects
2 Conceptual Design Formulated	1

Number of Projects 1

Title	Number	Page
Telerobotics Flight Experiment Definition	190-27	176

190-27

Title:
Telerobotics Flight Experiment Definition

Description:
Develop a plan and an early experiment concept for a telerobotics flight experiment. This is an intercenter activity, with JPL, LaRC,MSFC, and ARC.

Program: Spaceflight R&T Date: Jan 90
NASA Headquarters Program Code:
UPN/PWC: 506-48
Task no.: 9

Point of Contact: Lyle Jenkins Telephone: 283-5405
Division: IC - Technology and Commercial Projects Office

State: inactive

Categories Describing the Work of this Project:

2.4 Robotic and telerobotic systems
1.4 Human-machine interface
1.2 Sensing
1.3 Actuation and manipulation

2.4-5 Handling of parts
1.2-7 Force and torque
1.4-1 Controls
1.4-2 Displays
1.3-5 Control technology
1.3-8 Manipulators

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
2 Conceptual design formulated

Current Status:
The study was cancelled in March 1988 and funding withdrawn by OAST.

Schedule:
The project is inactive.

PROJECTS REPORTED BY NS - SAFETY DIVISION

Category:	Projects
1.4 Human-Machine Interface	2

Level of Technological Readiness at the End of FY90	Projects
Technology level not given	2

Number of Projects 2

Title	Number	Page
Artificial Intelligence and Robotics Flight Safety	190-2	179
Artificial Intelligence and Robotics Ground Safety	190-1	178

190-1

Title:
Artificial Intelligence and Robotics Ground Safety

Description:
Automation and Robotics ground test operations are supported. Automation and robotics ground facilities are assessed for hazards and resolution of hazards. Test readiness reviews, facility test design reviews, operational readiness inspections, and other meetings are supported.

Program: Space Station Date: Jan 90

Point of Contact: Dan Clem Telephone: 483-4272
Division: NS - Safety
Branch: Test Operations and Institutional Safety

State: low level

Categories Describing the Work of this Project:

1.4 Human-machine interface
2.1 Supporting software and hardware
2.3 Knowledge based or expert systems
2.4 Robotic and telerobotic systems

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
Level not given

Performing Organizations	Name of Contact	Telephone

Current Status:
Active

Schedule:
The schedule will support milestones for ground tests and facilities.

190-2

Title:
Artificial Intelligence and Robotics Flight Safety

Description:
Analyses of safety of automation and robotics on the Space Station are reviewed and approved; milestone reviews for the Space Station are supported. Failure modes and effects analyses or lists of critical items, results of sneak analyses, change analyses, etc. are kept in a data base for use in tracking issues, concerns, and hazards. A&R working groups are supported, and trade studies assessed.

Program: Space Station

Date: Dec 90

Point of Contact: Gary Priest
Division: NS - Safety
Branch: Avionics and Software Systems Safety
Section: Avionics Systems Safety

Telephone: 483-6219

State: low level

Categories Describing the Work of this Project:

1.4 Human-machine interface
2.1 Supporting software and hardware
2.3 Knowledge based or expert systems
2.4 Robotic and telerobotic systems

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
Level not given

Performing Organizations	Name of Contact	Telephone
CALSPAN	Donald Ganiere	(713) 334-2240

Current Status:
The project is active.

Schedule:
The schedule will support the Space Station milestones.

This page intentionally left blank.

PROJECTS REPORTED BY PT - INFORMATION TECHNOLOGY DIVISION

Category:		Projects
1.1	Knowledge	13
1.2	Sensing	1
1.3	Actuation and Manipulation	2
1.4	Human-Machine Interface	4
2.1	Supporting Software and Hardware	5
2.2	System Design and Integration	7
2.3	Knowledge-Based or Expert Systems	14
2.4	Robotic and Telerobotic Systems	9

Level of Technological Readiness at the End of FY90	Projects
1 Basic Principle Observed or Reported	1
2 Conceptual Design Formulated	4
3 Conceptual Design Tested	9
4 Critical Function or Characteristic Demonstrated	12
5 Component or Breadboard Tested in the Relevant Environment	5
6 Prototype or Engineering Model Tested in the Relevant Environment	14
7 Engineering Model Tested in Space	1
8 Full Operational Capability (incorporated in production design)	7
Technology level not given	2

Number of Projects 53

Title	Number	Page
A Back Propagation Simulator for the Hypercube	190-128	229
A Difference Optimized Training Scheme for the Neocognitron	190-143	233
AI Section/Man-Machine Interfaces	190-6	219
A Neural Network Based Technique for IR Spectral Analysis	190-127	228
A Unified Robotics Control System Using a Parallel CLIPS Environment	190-40	208
Adaptive Fuzzy Logic Control	190-134	202
An Accelerated Method for Back Propagation Networks	190-141	231
An Automatic Assistant for Scheduling and Planning for the Space Station	190-29	226
An Intelligent Tutoring System for High School Physics	190-113	197
AutoLib (Automated on-line Library)	190-105	188
Automated Grappling Control for the Shuttle RMS	190-31	205
Automated Software Development Workstation (ASDW) Phase II	190-101	184
Automatic Scheduling Using A Genetic Algorithm Approach	190-80	223
Automatic Perception for NASA Mission Planning and Flight Control	190-9	213
Automation and Expert System Applications for Planning and Scheduling	190-30	204
Autonomous Object Recognition for the EVA Retriever	190-50	245
CLIPS Intelligent Tutor (CLIPSIT)	190-23	215
C Language Integrated Production System (CLIPS)	190-24	217

Title	Number	Page
Computer Aided Software Engineering (CASE) Tools Review and Evaluation	190-103	186
Computer Graphics Testbed for Vision Systems to be Used in Space	190-38	207
Cooperating Expert Systems	190-11	193
Cooperative Agreement with MCC	190-108	191
Correlation-Based Synthetic discriminate Filter for Image Segmentation	190-140	230
Demonstration of a 3D Vision Algorithm for Space Applications	190-39	227
Develop Neural Network Computer System	190-7	221
Development and Experimentation of Eye/Brain/Task Test Bed	190-8	249
Development of an Ada-Based Version of ART	190-12	201
Expert System for Shuttle Electrical Power Management	190-55	247
Fuzzy Ring Network for Machine Vision	190-142	232
General Purpose Development Environment for ICAT Systems	190-111	195
Greyscale Morphology in Machine Vision	190-35	240
Historical Software Development Cost Data Base	190-104	187
Instrument Pointing System/Intelligent Computer Aided Training System	190-115	199
Intelligent Computer-Aided Training (ICAT)	190-158	237
Intelligent Computer-Aided Training System for PAM Deploys	190-157	235
Intelligent Evaluation System for Simulator Training	190-114	198
Machine Vision using Artificial Neural Network Simulations	190-32	206
Main Propulsion Pneumatics/Intelligent Computer-Aided Training System	190-112	196
NETS: A Tool for the Development and Delivery of Neural Networks	190-4	242
Neural Network Simulation on Class VI Computers	190-3	238
On-Board Navigation Expert System	190-81	225
Payload-Assist Module Deploy/Intelligent Computer-Aided Training System	190-79	211
Phoneme Based Speech Recognition for Mission Planning and Control	190-10	183
Resource Planning and Management Expert System	190-49	243
Robot Path Planning Using Genetic Algorithms	190-33	239
SERC/PCEE	190-109	192
SIM Tool	190-106	189
Software Cost Modeling and Automated Data Collection	190-110	194
Software Life Cycle Support Environment (SLCSE) Beta Test	190-102	185
Software Reengineering/Reuse	190-107	190
Space Station Mission Requirements Data Bases	190-54	246
Spatiotemporal Neural Network Systems	190-5	244
Support Technologies Development	190-51	209
The Parametric Avalanche Control Module Prototype Development	190-28	203
The Use of Fuzzy Set Theory in Controlling Failures in Space Systems	190-37	241

190-10

Title:
Phoneme Based Speech Recognition for Mission Planning and Control

Description:
Develop a system for continuous recognition of speech to operate in real time and in situations of high stress.

Program: Shuttle

Date: Dec 90

Point of Contact: James Villarreal
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8076

State: Active

Categories Describing the Work of this Project:

1.4 Human-machine interface

1.4-13 Voice recognition

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
5 Component or breadboard tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
Speech Systems, Incorporated	Bill Meisel	(818) 881-0885

Current Status:
A demonstration of accuracy of recognition of speech is scheduled for June 1987.
Studies of stress will be completed in June 1987.
A data base for a model of a speaker who comes from the southern United States has been collected.

Schedule:
5000 word dictionary of words specific to NASA completed: May 87
Syntaxes created: Jul 87
Recognition under stressful conditions tested: Aug 87

190-101

Title:
Automated Software Development Workstation (ASDW) Phase II

Description:
Phase IV focuses on field testing and enhancements to the software parts composition system component of ASDW. A graphical user interface will be defined. Tools for acquiring and integrating knowledge during the early phases of the software life cycle will be provided. A technique to supply expert knowledge to users of applications developed on ASDW will be researched.

Program: Advanced Programs — Date: Jan 90
NASA Headquarters Program Code: M, S

Point of Contact: Ernest M. Fridge, III — Telephone: 483-8109
Division: PT - Information Technology
Branch: Software Technology

State: Active

Categories Describing the Work of this Project:

2.2 System design and integration

2.2-4 Automated software development

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Performing Organizations	Name of Contact	Telephone
Inference Corporation	Brad Allen	(213) 417-7997
SOFTECH	John McBride	(713) 480-1994
KBSI	Rick Mayer	(409) 845-9363

Current Status:
Current work continues: methods for handling scale-up problems, automatic generation of the taxonomy, and techniques for development of graphical interfaces. The technology for the ASDW is field tested on projects that support SSFP mission planning and analysis. Phase IV will also define the "framework," the integration platform, and the ESL.

Schedule:
Phase II was demonstrated in March 1988.
The Phase III prototype was demonstrated in February 1989.
Phase III complete: Dec 31, 1989
Phase IV will define the ESL, the "Framework," and the "integration platform," and provide support to field testing of the parts composition system.

190-102

Title:
Software Life Cycle Support Environment (SLCSE) Beta Test

Description:
SLCSE is being beta tested to evaluate its functionality, and to assess its applicability in supporting software projects. Capabilities include software life cycle support for multi-project, multi-language environments; rapid prototyping; automated quality metric collection, Ada verification, and document generation; requirements engineering; user roles; data model; and integrated object base.

Program: Advanced Programs
UPN/PWC: 569-21

Date: Feb 90

Point of Contact: Ernest M. Fridge, III
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8109

State: Active

Categories Describing the Work of this Project:

1.1 Knowledge
1.4 Human-machine interface
2.2 System design and integration

1.1-1 Acquisition of knowledge
1.4-7 Management of user interfaces
2.2-4 Automated software development
2.2-10 Validation and verification

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
3 Conceptual design tested

Performing Organizations	Name of Contact	Telephone
The MITRE Corporation	Lois Morgan	

Current Status:
The task started in January, 1990. The software and hardware environments are being set up.

Schedule:
Beta testing should be completed by October 1990.

190-103

Title:
Computer Aided Software Engineering (CASE) Tools Review and Evaluation

Description:
Provide information for strategic planning for directing CASE research toward promising unsolved problems and areas of research. The focus will be the current state of CASE technology and projections for the future. A supporting objective is effective evaluation of the the state of CASE technology and comparison with the status of research and development of tools; criteria for evolution will be developed.

Program: STS
UPN/PWC: 569-21

Date: Feb 90

Point of Contact: Ernest M. Fridge, III
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8109

State: Active

Categories Describing the Work of this Project:

1.1 Knowledge

1.1-1 Acquisition of knowledge

Funded: yes

Expected Level of Technology at the End of the Fiscal Year
1 Basic principle observed or reported

Performing Organizations	Name of Contact	Telephone
The MITRE Corporation	Dona Erb	

Current Status:
The task will start in January 1990.

Schedule:
A data base of evaluations of today's best CASE products will be completed in FY90.

190-104

Title:
Historical Software Development Cost Data Base

Description:
Historical data on the cost of software development for new technologies will be added to the existing data base of software development cost. Data bases of Dr. Barry Bochner and the GSFC Software Engineering Laboratory will be included. The final data base must include project data for the different kinds of software technologies desired such as knowledge based systems, fourth generation languages, and Ada.

Program: Advanced Programs
UPN/PWC: 476-23

Date: Feb 90

Point of Contact: Ernest M. Fridge, III
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8109

State: Active

Categories Describing the Work of this Project:

2.2 System design and integration
2.3 Knowledge based or expert systems

2.2-4 Automated software development
2.3-11 Programming support
2.3-10 Planning
2.3-12 Scheduling

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
The MITRE Corporation	Dan LaBasse	

Current Status:
An existing data base of NASA projects from the 1980's contains complete data for 100 projects, plus partial data for 150 projects. This task to add data on new technology started in January, 1990.

Schedule:
Analysis of Dr. Barry Boehm's data base and the GSFC data base should be complete by September, 1990.

190-105

Title:
AutoLib (Automated on-line Library)

Description:
AutoLib automates the cataloging and retrieval of information and objects in a large, distributed, heterogeneous environment. Objects can include program source code, executable, design specifications and drawings, data, and documents. An object management approach and hypermedia features are used in a system that is usable now. New features and enhancements are made upon user requests.

Program: STS
UPN/PWC: 569-21

Date: Feb 90

Point of Contact: Ernest M. Fridge, III
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8109

State: Active

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems

2.3-4 Engineering support

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
8 Full operational capability (incorporated in production design)

Performing Organizations	Name of Contact	Telephone
Barrios Technology Inc.	Robert Hennan	(713) 280-1839

Current Status:
AutoLib is currently used in the Mission Planning and Analysis Division: in the prototype tools for the CALS document prototype, and is being implemented into FADS as the archive library. It is being implemented in the Engineering directorate for use in graphics and for design knowledge capture.

Schedule:
Version 3.0 delivered: January 1990
Graphics and design knowledge capture planned: September 1990

190-106

Title:
SIM Tool

Description:
Tools for high-fidelity vehicle simulation and construction of state-of-the-art graphics are integrated in an interface highly oriented to the end-user. A "point-and-click" user interface accesses the latest technology in simulation and graphics architecture. A user describes a simulation in high-level graphical form; automatic code generation techniques produce a simulation application.

Program: SBIR
UPN/PWC: SBIR

Date: Feb 90

Point of Contact: Ernest M. Fridge, III
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8109

State: Active

Categories Describing the Work of this Project:

2.2 System design and integration
1.4 Human-machine interface

2.2-4 Automated software development
1.4-6 Interfaces to knowledge based or expert systems

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
3 Conceptual design tested

Performing Organizations	Name of Contact	Telephone
LINCOM	Dan Bochsler	(713) 488-5700

Current Status:
Phase I is complete. Phase II will start in March 1990.

Schedule:
Phase I is complete.
Phase II starts March 1990, and lasts for 2 years.

190-107

Title:
Software Reengineering/Reuse

Description:
Provide technology required to reengineer the huge existing base of NASA computer software to provide better maintenance, reuse, and conversion to newer computer technologies. The existing code will remain for many years and must be updated to newer languages such as Ada, or, at a minimum, to new standards approved for existing languages, e.g. FORTRAN 77 may have to move to FORTRAN 88.

Program: STS
NASA Headquarters Program Code:
UPN/PWC: 569-21

Date: Feb 90

Point of Contact: Ernest M. Fridge, III
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8109

State: Active

Categories Describing the Work of this Project:

2.2 System design and integration
2.3 Knowledge based or expert systems
1.4 Human-machine interface

2.2-4 Automated software development
2.3-4 Engineering support
1.4-11 Reprogramming interfaces

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Performing Organizations	Name of Contact	Telephone
Barrios Technology Inc.	Allan Plumb	(713) 280-1879

Current Status:
A standard for FORTRAN exists that provides for easier comparison and maintenance. A strawman definition of the environment to support this standard is available. A conversion methodology exists. A test project moving 18kLOC of FORTRAN to Ada is about 70% complete.

Schedule:
FORTRAN test case completed: July 1990
Environment prototype completed: July 1991

190-108

Title:
Cooperative Agreement with MCC

Description:
A group of NASA organizations are exploring the research at MCC (Microelectronic and Computer Technology Corp.) to determine if JSC should enter into cooperative projects to bring MCC research into NASA. Research being investigated covers graphical interfaces, design recovery and reuse, distributed system design languages, groupware and coordination of activity, and software integration platforms.

Program: Advanced Programs

Date: Feb 90

Point of Contact: Ernest M. Fridge, III
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8109

State: Active

Categories Describing the Work of this Project:

1.4 Human-machine interface
2.2 System design and integration

1.4-6 Interfaces to knowledge based or expert systems
1.4-11 Reprogramming interfaces
2.2-4 Automated software development

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
Level not given

Performing Organizations	Name of Contact	Telephone
MCC	Brian Fugate	(512) 338-3330

Current Status:
"Hands on" experience with graphical tools is underway. Activity in the other areas includes reading MCC documentation, seeing demonstrations, and talking with MCC researchers.

Schedule:
Long-term projects will be determined by July 1990.

190-109

Title:
SERC/PCEE

Description:
The Software Engineering Research Center/Portable Common Execution Environment considers problems of extremely large, complex, distributed computer systems with components that are mission and safety critical and must operate nonstop for many years. It includes the host and integration environments for developing a system and delivering and monitoring the operational system, and the operational environment.

Program: Space Station
NASA Headquarters Program Code: R
UPN/PWC: 506

Date: Feb 90

Point of Contact: Ernest M. Fridge, III
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8109

State: Active

Categories Describing the Work of this Project:

2.1 Supporting software and hardware
2.3 Knowledge based or expert systems

2.1-2 Distributed systems
2.1-3 Fault-tolerant architecture
2.3-8 Management of faults
2.3-9 Monitoring
2.3-11 Programming support

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
2 Conceptual design formulated

Performing Organizations	Name of Contact	Telephone
University of Houston - Clear Lake	Dr. Charles McKay	(713) 283-3830
SOFTECH	D. Auty	(713) 480-1994

Current Status:
The basic hardware for the single processor testbed is undergoing checkout for the PCEE. For SERC, the NIST is being supported with the software life cycle method, and the Ada Runtime Working group is being supported.

Schedule:
Four major deliveries per year are scheduled through FY96. These are phased to support the SSE CDR and the PDR and CDR for SSFP. Later deliveries will be fed to the SSFP community annually.

190-11

Title:
Cooperating Expert Systems

Description:

Demonstrate cooperating expert systems on a network of workstations in the AUTOPS testbed. Codify the current state of the art in cooperating expert systems. Characterize the degree of cooperation between agents that is desirable. Characterize and develop an architecture for cooperating expert systems. Define tools needed to support development of cooperating expert systems. Demonstrate a prototype.

Program: Systems Autonomy
NASA Headquarters Program Code: RC

Date: June 89

Point of Contact: Chris Culbert
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8080

State: Active

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems

2.3-3 Distributed expert systems
2.3-7 Interacting expert systems
2.3-5 Executives for expert systems

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Performing Organizations	Name of Contact	Telephone
McDonnell Douglas Space Systems Company	Jorge Rufat	(713) 283-4308

Current Status:
Will start in FY90

Schedule:
Report on literature search: an 90
Requirements for cooperating expert systems: Jun 90
Demonstration of the initial prototype: Sep 90
Demonstration of the full prototype: Mar 91

190-110

Title:
Software Cost Modeling and Automated Data Collection

Description:
Use COCOMO (Constructive Cost Model), a method for estimating the cost of software, in developing a model for software cost that is capable of handling software to be developed for the space station program. Cost data will be trapped automatically, and used to maintain the accuracy of the model and assist in tuning project costs with actual data from the project.

Program: Space Station

Date: Jan 90

Point of Contact: B. Roush

Telephone: 483-9092

Division: PT - Information Technology
Branch: Software Technology

State: operational

Categories Describing the Work of this Project:

2.1 Supporting software and hardware

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
3 Conceptual design tested

Performing Organizations	Name of Contact	Telephone
The MITRE Corporation	Dan LaBasse	

Current Status:
The basic cost model has been developed. Automated data collection has not started yet. Level II decided to move this work to the SSE; A capability is being added for providing cost estimating for new software technologies such as knowledge based systems is being added. The program is operational; support for new software technologies is being researched.

Schedule:
Continue to collect historical data on costs.
Calibrate the model to reflect the NASA environments.
Enhance the model to handle new technologies.

190-111

Title:
General Purpose Development Environment for ICAT Systems

Description:
Develop an environment to facilitate the production of Intelligent Computer-Aided Training (ICAT) Systems. The environment will be based on the general ICAT architecture developed in the PD/ICAT project. Software tools to be developed will aid in knowledge acquisition, development of user interfaces, interfacing with data bases, speech recognition, editing of knowledge bases, and system integration.

Program: Advanced Programs
Date: Jan 90
NASA Headquarters Program Code: ST

Point of Contact: Robert T. Savely
Telephone: 483-8105
Division: PT - Information Technology
Branch: Software Technology

State: Active

Categories Describing the Work of this Project:

1.1 Knowledge
1.4 Human-machine interface
2.2 System design and integration
2.3 Knowledge based or expert systems

1.1-1 Acquisition of knowledge
1.1-2 Control methods
1.4-2 Displays
2.2-4 Automated software development
2.2-9 Shells for knowledge based or expert systems
2.3-7 Interacting expert systems

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
3 Conceptual design tested

Performing Organizations	Name of Contact	Telephone
University of Houston - Downtown	R. Bowen Loftin	(713) 221-8015
Computer Sciences Corporation	Steve Baudendistel	(713) 280-2430

Current Status:
Development of requirements and evaluation of software and are in progress.

Schedule:
Evaluation and development of requirements: Oct 88 - Sep 90
Development of tests: Jan 90 - Sep 91
Integration and testing: Mar 91 - Feb 93
Final delivery: Sep 93

190-112

Title:
Main Propulsion Pneumatics/Intelligent Computer-Aided Training System

Description:
Develop an Intelligent Computer-Aided Training (ICAT) system to train engineers in testing the Space Shuttle main propulsion system. The ICAT system will prepare engineers to follow proper checkout procedures and do troubleshooting on the system.

Program: Shuttle

Date: Jan 90

Point of Contact: Robert T. Savely
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8105

State: Active

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems
1.4 Human-machine interface
1.1 Knowledge

2.3-7 Interacting expert systems
1.4-2 Displays
1.1-1 Acquisition of knowledge
1.1-2 Control methods
1.1-4 Diagnosis
1.1-14 Simulation

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
University of Houston - Downtown	R. Bowen Loftin	(713) 221-8015
Computer Sciences Corporation	Steve Baudendistel	(713) 280-2430
Kennedy Space Center	Ashrod Heard	(407) 867-2780

Current Status:
The project was initiated in January 1989.
The first prototype is being developed.

Schedule:
First prototype delivered: Oct 89
Final delivery: Jan 91

190-113

Title:
An Intelligent Tutoring System for High School Physics

Description:
Develop an intelligent tutoring system that will enable a student to acquire the skill in applying the concepts of physics in solving problems that is needed for mastery of high school or introductory college physics. The complexity of problems presented to the student will be increased at a rate suited to the individual. The tutor will be capable of being integrated with a typical instructional program.

Program: Technology Utilization

Date: Jan 90

Point of Contact: Robert T. Savely
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8105

State: Active

Categories Describing the Work of this Project:

1.1 Knowledge
1.4 Human-machine interface
2.3 Knowledge based or expert systems

1.1-10 Problem solving
1.1-1 Acquisition of knowledge
1.1-2 Control methods
1.1-4 Diagnosis
1.4-2 Displays
2.3-1 Control

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
University of Houston - Downtown	R. Bowen Loftin	(713) 221-8015
Computer Sciences Corporation	Steve Baudendistel	(713) 280-2430

Current Status:
The second prototype has been developed and is being tested.

Schedule:
Initiated: Oct 88
First prototype: Feb 89
Second prototype: Jun 89
Completion anticipated: Sep 91

190-114

Title:
Intelligent Evaluation System for Simulator Training

Description:
Provide a system, to run during or after a simulation, that will provide a student with tutorial information on performance, with advice and explanations. Initially, the evaluation will be performed after the lesson. If the approach proves to be feasible, evaluation in real-time will be investigated.

Program: Shuttle

Date: Jan 90

Point of Contact: Robert T. Savely

Telephone: 483-8105

Division: PT - Information Technology
Branch: Software Technology

State: Active

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems

2.3-6 Hybrid expert systems

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
University of Houston - Downtown	R. Bowen Loftin	(713) 221-8015
Global Information Systems Technology, Inc.	Diann Barbee	(217) 352-1165

Current Status:
The current focus of the project is on ancillary training for SMS and SES.

Schedule:
Phase I SBIR awarded: February 1987
Phase I Final Report: June 1988
Phase II SBIR awarded: July 1989
Completion date: August 1991

190-115

Title:
Instrument Pointing System/Intelligent Computer Aided Training System

Description:
Develop an autonomous Intelligent Computer Aided Training system (ICAT) for use at MSFC and JSC for training Mission Specialists and Pointing Specialists in the use of the Instrument Pointing System (IPS). The system will encompass activation, calibration, and deactivation of the IPS and nominal and malfunction procedures for use with selected experiment apparatuses.

Program: Shuttle

Date: Feb 90

Point of Contact: Robert T. Savely
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8105

State: Active

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems
1.1 Knowledge
1.4 Human-machine interface
2.2 System design and integration

2.3-7 Interacting expert systems
2.3-10 Planning
1.1-10 Problem solving
1.1-12 Representation and reasoning
1.4-6 Interfaces to knowledge based or expert systems
2.2-8 Knowledge engineering

Funded: yes

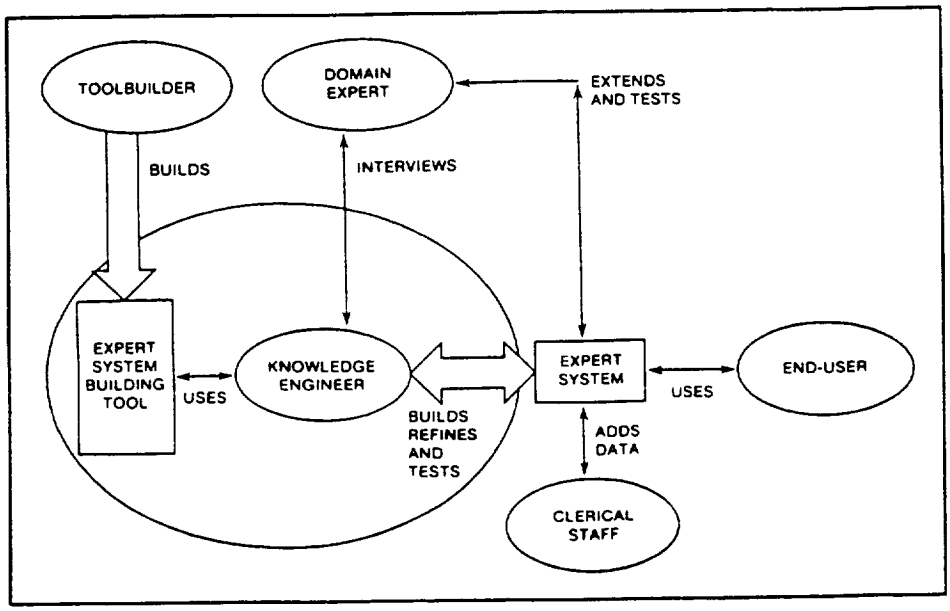
Expected Level of Technology at the End of the Fiscal Year:
2 Conceptual design formulated

Performing Organizations	Name of Contact	Telephone
University of Houston - Downtown	R. Bowen Loftin	(713) 221-8015
Computer Sciences Corporation	Steve Mueller	(713) 280-2221

Current Status:

Schedule:
Project initiation: August 89
Interface design: November 89
First D.E. prototype: February 90
Second D.E. prototype: August 90

The players in expert systems development.



190-12 Development of an Ada-based version of ART.

190-12

Title:
Development of an Ada-Based Version of ART

Description:
Use Ada to develop a state-of-the-art tool for constructing expert systems. NASA will receive copies of ART (Automated Reasoning Tool) written in Ada with documentation and maintenance for one year.

Program: Advanced Programs

Date: Dec 90

Point of Contact: Chris Culbert
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8080

State: Active

Categories Describing the Work of this Project:

2.1 Supporting software and hardware

2.1-5 Programming languages

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
5 Component or breadboard tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
Inference Corporation	Brad Allen	(213) 417-7997

Current Status:
The Phase 2 prototype was demonstrated in March 1989.
CLIPS in Ada will be completed in September 1989.

Schedule:
Extended beta testing of the ART/Ada prototype will begin in January 1989.
Evaluation will be completed by July 1990.

190-134

Title:
Adaptive Fuzzy Logic Control

Description:
Explore the use of fuzzy logic in optimization and adaptive control that 1) adapts to the problem at hand and functions acceptably under abnormal conditions, 2) is able to evaluate current data and circumstances and make changes as the environment changes, and 3) uses a rule based approach. Develop a prototype system and test environment for evaluating applications and testing of candidate methods.

Program: Advanced Programs
NASA Headquarters Program Code: M

Date: Mar 90

Point of Contact: Robert Lea
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8085

State: Active

Categories Describing the Work of this Project:

1.1 Knowledge
1.3 Actuation and manipulation
1.4 Human-machine interface
2.3 Knowledge based or expert systems

1.1-2 Control methods
1.3-5 Control technology
1.4-4 Fusion of sensors
2.3-1 Control

Funded: yes

Expected Level of Technology at the End of the Fiscal Year
2 Conceptual design formulated

Performing Organizations	Name of Contact	Telephone
University of Southern California	Bart Kosko	(213) 743-6581
Associated Dynamics	Cleveland Donnelly	(213) 271-9896
Togai Infralogic	Carl Perkins	(714) 975-8522

Current Status:
Fuzzy logic controllers have been built for control of space vehicles and to control processing of sensor data; testing has been started. Further testing will be done and adaptive controllers tested in these and similar systems such as positioning of robotics arms, and camera tracking control. Applications of fuzzy logic to image processing for robotics are being considered.

Schedule:
Phase 1: Concepts for adaptive controllers will be developed. A preliminary design for a controller will be developed and tested to a limited extent by the end of FY90. For later phases, in FY91 and FY92, a space station test environment will be developed and the performance of candidate adaptive controllers tested and evaluated in depth.

190-28

Title:
The Parametric Avalanche Control Module Prototype Development

Description:
Successful completion of this project will demonstrate a powerful new algorithm for adaptive control in the context of a known problem. Such an algorithm could be applied to a wide range of control problems with only minimal modifications. The algorithm will "learn" a new control problem by experience rather than requiring a programmer to encode problem-specific know-ledge in the form of rules or equations.

Program: SBIR

Date: Feb 90

Point of Contact: Robert O. Shelton
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-5901

State: Active

Categories Describing the Work of this Project:

1.3 Actuation and manipulation
1.1 Knowledge
1.2 Sensing
2.1 Supporting software and hardware

1.3-5 Control technology
1.1-2 Control methods
1.1-6 Learning
1.2-8 Integrating sensor information
2.1-2 Distributed systems
2.1-3 Fault-tolerant architecture

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Performing Organizations	Name of Contact	Telephone
Martingale Research Corporation	Dr. Robert L. Dawes	(214) 422-4570

Current Status:

Schedule:

190-30

Title:
Automation and Expert System Applications for Planning and Scheduling

Description:
Develop planning and scheduling tools that are independent of the application and can be applied to a wide variety of problems including planning and replanning of ground operations for STS flights. A library of Ada and X-Windows components including representations for time, activities, and resources, and algorithms for scheduling activities and resources will be available in an interactive system.

Program: Shuttle
NASA Headquarters Program Code: IN
UPN/PWC: 906-21-03
Task no.: NAS9-17885

Date: Jan 5, 1990

Point of Contact: Ervin O'Neal Grice
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8082

State: Active

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems

2.3-12 Scheduling

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
McDonnell Douglas Space Systems Company	Barry R. Fox	(713) 280-1500

Current Status:
Continuing at a high level of effort.

Schedule:
First delivery: June 30, 1989
First release: October, 1989
Second release: June 30, 1990

190-31

Title:
Automated Grappling Control for the Shuttle RMS

Description:
Automate control of the magnetic end effector using the existing Targeting and Reflecting Alignment Concept, TRAC, together with techniques for machine vision and artificial intelligence. This is a cooperative effort among the Space Systems Division, Engineering Directorate, Mission Planning and Analysis Division, New Initiatives Office, and the existing support contractors.

Program: Shuttle

Date: Jan 90

Point of Contact: Dr. T. F. Cleghorn
Telephone: 483-8090
Division: PT - Information Technology
Branch: Software Technology

State: Active

Categories Describing the Work of this Project:

1.1 Knowledge
1.2 Sensing
1.3 Actuation and manipulation

1.1-11 Recognition of objects
1.2-14 Visual and optical
1.3-7 End effectors
1.3-5 Control technology

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Performing Organizations	Name of Contact	Telephone
Lockheed Engineering & Sciences Company	Les Theard	(713) 333-7301

Current Status:
The project is beginning.

Schedule:
Shuttle, Space Station, general robotics operations.

190-32

Title:
Machine Vision using Artificial Neural Network Simulations

Description:
Use neural network technology in machine vision to be used in space. A contract is being prepared for obtaining a neural net controller for a robot arm. Machine vision input is used to drive the arm, and to permit it to "learn" about its environment. This project is currently funded at the 50K level. A simulation will be developed, and ultimately adapted to real arms at JSC.

Program: Advanced Programs

Date: Dec 89

Point of Contact: Dr. T. F. Cleghorn
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8090

State: Active

Categories Describing the Work of this Project:

2.4 Robotic and telerobotic systems
1.2 Sensing

2.4-3 Computer vision systems
1.2-14 Visual and optical

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
Neurogen, Inc.	Dr. Michael Kuperstein	(617) 232-8266

Current Status:
The project will be initiated in January 1990.

Schedule:
Year 1 - Develop simulation for manipulating static objects and avoiding collisions.
Year 2 - Move to a real robot arm.
Year 3 - Add a dynamic environment.

190-38

Title:
Computer Graphics Testbed for Vision Systems to be Used in Space

Description:
Use computer graphics to create a test bed for algorithms for machine vision for autonomous and remotely controlled robotics for servicing satellites. Include path planning and collision avoidance for a mobile vehicle using a laser mapper that provides input to an artificial neural net. Provide video images of a model to illustrate control of a robot arm using feedback.

Program: Advanced Programs
UPN/PWC: NCC 9-16

Date: Dec 89

Point of Contact: Dr. T. F. Cleghorn
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8090

State: Active

Categories Describing the Work of this Project:

2.4 Robotic and telerobotic systems

2.4-3 Computer vision systems

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
8 Full operational capability (incorporated in production design)

Performing Organizations	Name of Contact	Telephone
Rice University	Prof. John Cheatham	(713) 527-4822

Current Status:
Models have been built. Multi-arm work is well under way. Forward planning, expert systems, and neural nets are being used. Integration of multiple sensor data for autonomous servicing of satellites, and development of techniques for voice control of remote platforms continues. The initial path planner has been delivered. An improved path planner and a mobile base and arm are being developed.

Schedule:
Images of prescribed motion completed: Dec 86
Control of light direction, hue, and shading completed: Apr 87
Robot arm controlled from camera images: Jun 87
Demonstration of the system and delivery of the software: Sep 87
Expand the program to include a multi-arm, multi-sensor system: Sep 88
Extend the program to include a neural net path planner: 1989

190-40

Title:
A Unified Robotics Control System Using a Parallel CLIPS Environment

Description:
Parallel CLIPS will be used to control a model of an automated factory. It will include multiple sensors, multiple cooperative robot arms, monitoring consoles, and computer systems for high-speed processing. The end products will include documentation of the system; advice on similar systems for robotic operations in space; and source code for implementing similar robotic systems for use in space.

Program: Advanced Programs

Date: June 89

Point of Contact: Dr. T. F. Cleghorn
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8090

State: Active

Categories Describing the Work of this Project:

2.4 Robotic and telerobotic systems

2.4-4 Construction

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
7 Engineering model tested in space

Performing Organizations	Name of Contact	Telephone
University of Lowell	Prof. Patrick Krolak	(508) 452-5000 ext 2693

Current Status:
One version of PCLIPS is hosted on a hypercube in building 30, the other on an Apollo system at Rockwell. Receipt of updates continues. PCLIPS is being integrated into the "Factory of the Future" at the University of Lowell in Massachusetts and, at WANG Laboratories, Inc., into a real factory for multiprocess planning, control, and quality evaluation. The Wang project is entering its second year.

Schedule:

190-51

Title:
Support Technologies Development

Description:
Describe technologies for operations that are in R&D in terms of the functions of MOD. Identify existing systems by "vintage". Identify strengths and weaknesses of current technologies. Develop criteria for evaluation. Match technologies and MOD requirements. Develop a data base of technologies that support Mission Operations. Develop a plan for infusing technologies into the flight operations process.

Program: Mission Operations Efficiency Study
NASA Headquarters Program Code: IC
Task no.: 4

Date: Jan 90

Point of Contact: Chris Culbert
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8080

State: Active

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems
1.4 Human-machine interface

2.3-2 Data base management
2.3-10 Planning
1.4-9 Options for levels of automation
1.4-12 Tradeoffs for automation

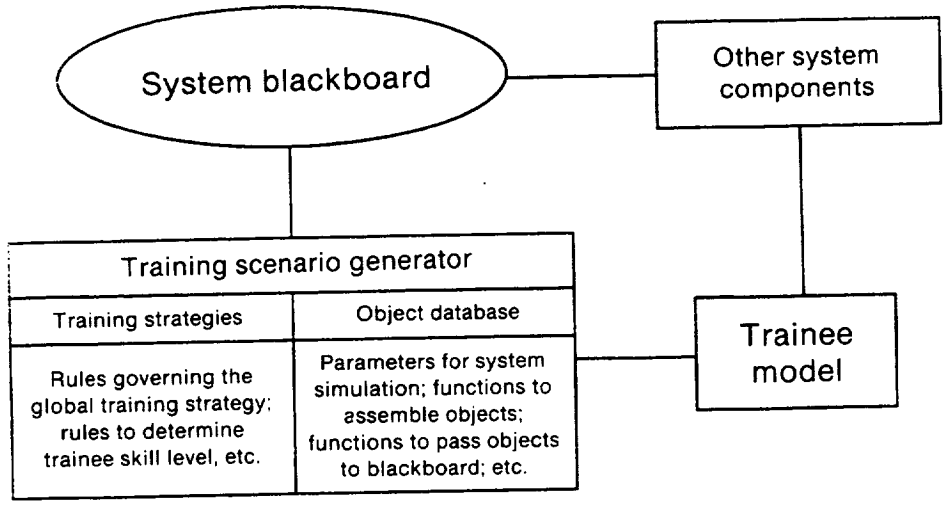
Funded: yes

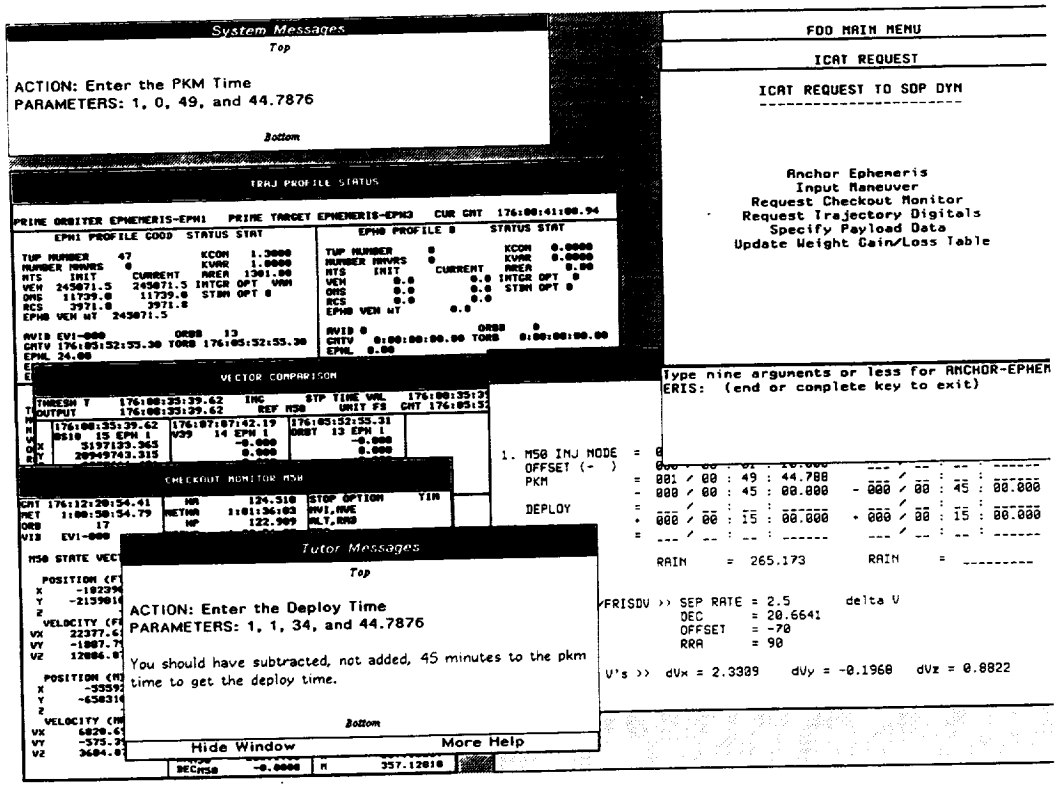
Expected Level of Technology at the End of the Fiscal Year:
3 Conceptual design tested

Performing Organizations	Name of Contact	Telephone
McDonnell Douglas Space Systems Company	Jonathan Weiss	(713) 283-4347
LINCOM	Dan Bochsler	(713) 488-5700

Current Status:
Technologic data is being gathered, requirements for a database are being defined, and a user profile is being established.

Schedule:
Identify criteria, specify operational requirements, identify sources for information on MOST (Mission Operations Support Technology), begin gathering data, and developing the user interface: By the end of FY89 Deliver MOST information data base, with real data: April 1990
Recommend technologies: August 1990
Integration plan: end of FY90





190-79 Payload assist module deploy/intelligent computer-aided training system.

190-79

Title:
Payload-Assist Module Deploy/Intelligent Computer-Aided Training System

Description:
Design a system to use in training flight dynamics officers in the development of payloads that will use the payload assist module. An intelligent computer-aided training system for use in the Mission Control Center in training flight controllers in deployment of the Payload-Assist Module has been completed. Current activity includes final testing and rehosting of software to an Apollo workstation.

Program: Shuttle
NASA Headquarters Program Code: MD
UPN/PWC: 906

Date: Jan 90

Point of Contact: Lui Wang
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8074

State: Active

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems
1.1 Knowledge
1.4 Human-machine interface

2.3-1 Control
2.3-4 Engineering support
2.3-7 Interacting expert systems
1.1-14 Simulation
1.4-6 Interfaces to knowledge based or expert systems
1.4-13 Voice recognition

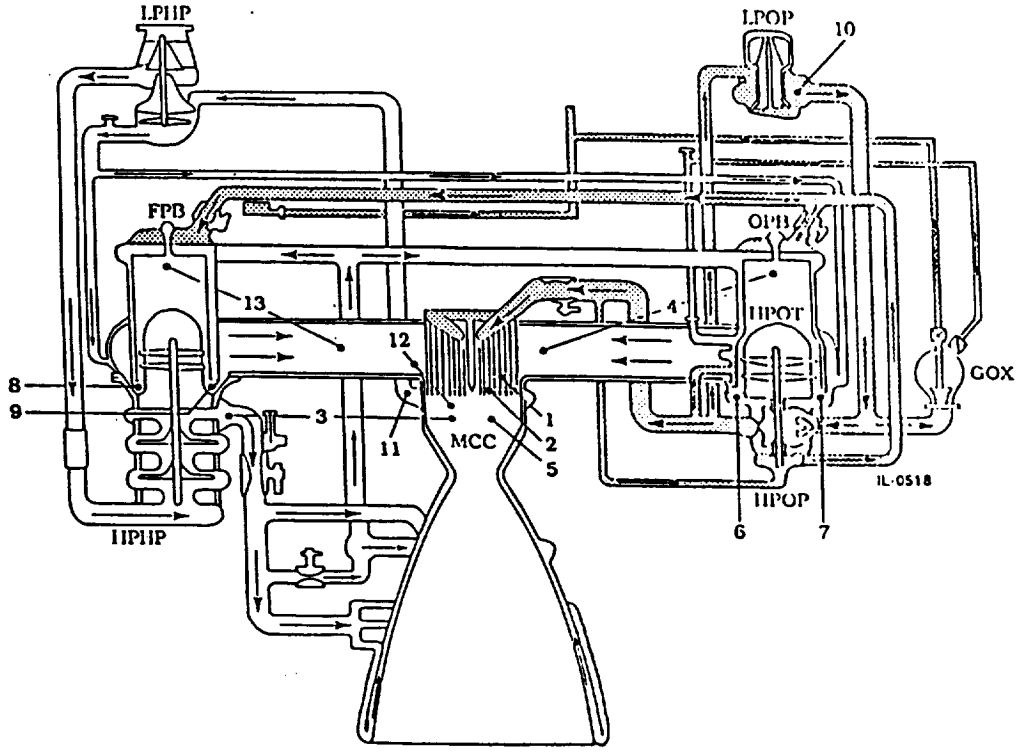
Funded: yes

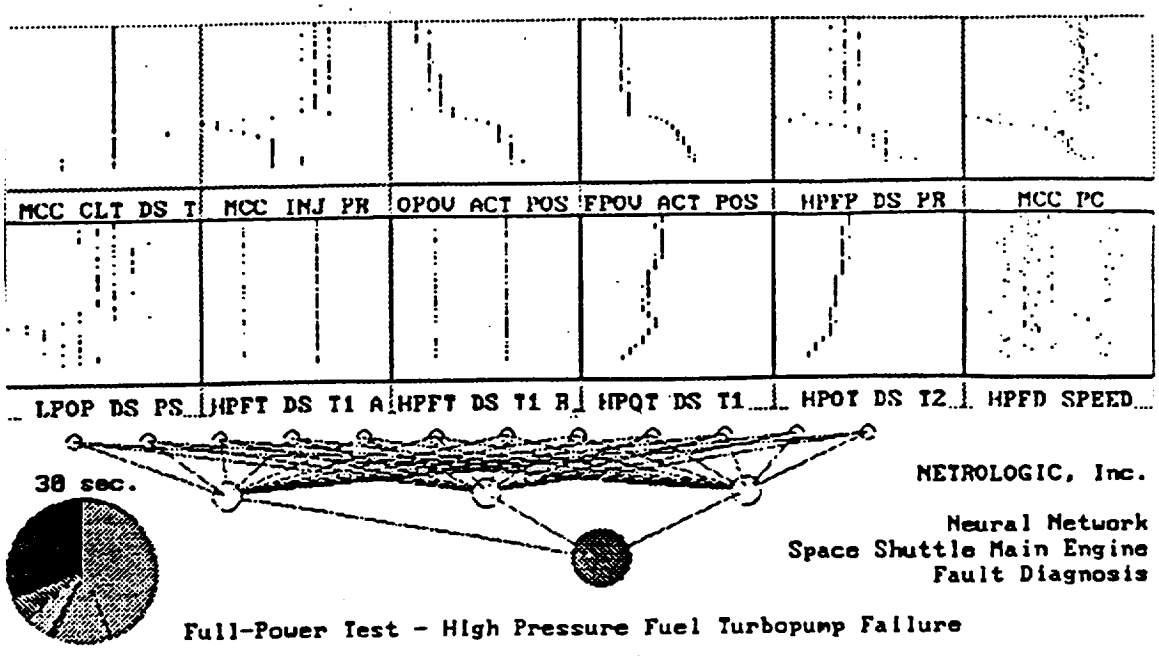
Expected Level of Technology at the End of the Fiscal Year:
8 Full operational capability (incorporated in production design)

Performing Organizations	Name of Contact	Telephone
University of Houston - Downtown	R. Bowen Loftin	(713) 221-8015
Computer Sciences Corporation	Steve Baudendistel	(713) 280-2430

Current Status:
The system is complete and operational on the Symbolics computer.
Testing and rehosting to the Apollo workstation is in progress.

Schedule:
Delivery on the Masscomp workstation: Mar 90





190-9 Automatic perception for NASA mission planning and flight control.

190-9

Title:
Automatic Perception for NASA Mission Planning and Flight Control

Description:
Determine the feasibility of applying neural network technology in machine perception and pre-planning for missions.

Program: Advanced Programs

Date: Dec 90

Point of Contact: James Villarreal
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8076

State: Active

Categories Describing the Work of this Project:

1.1 Knowledge

1.1-9 Planning

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
3 Conceptual design tested

Performing Organizations	Name of Contact	Telephone
Metrologic	Dan Greenwood	(619) 273-1225

Current Status:
The Phase II SBIR contract has been awarded. It will concentrate on applying neural network technology during preparations for launch: specifically, to monitoring and diagnosis of the health of the rocket engine. Preliminary experiments are being carried out that involve the integration of neural nets into the SSME.

Schedule:
Investigate neural network algorithms for use in machine perception: Apr 87
Provide Benchmarks: Jun 87
Final Report: July 87

This page intentionally left blank.

190-23

Title:
CLIPS Intelligent Tutor (CLIPSIT)

Description:
Develop a tutoring system to teach the basic concepts of rule-based programming. CLIPSIT will teach the development of rule-based programs using the C Language Integrated Production System (CLIPS).

Program: Advanced Programs

Date: Jan 90

Point of Contact: Gary Riley

Telephone: 483-8073

Division: PT - Information Technology
Branch: Software Technology
Section:

State: Active

Categories Describing the Work of this Project:

2.2 System design and integration

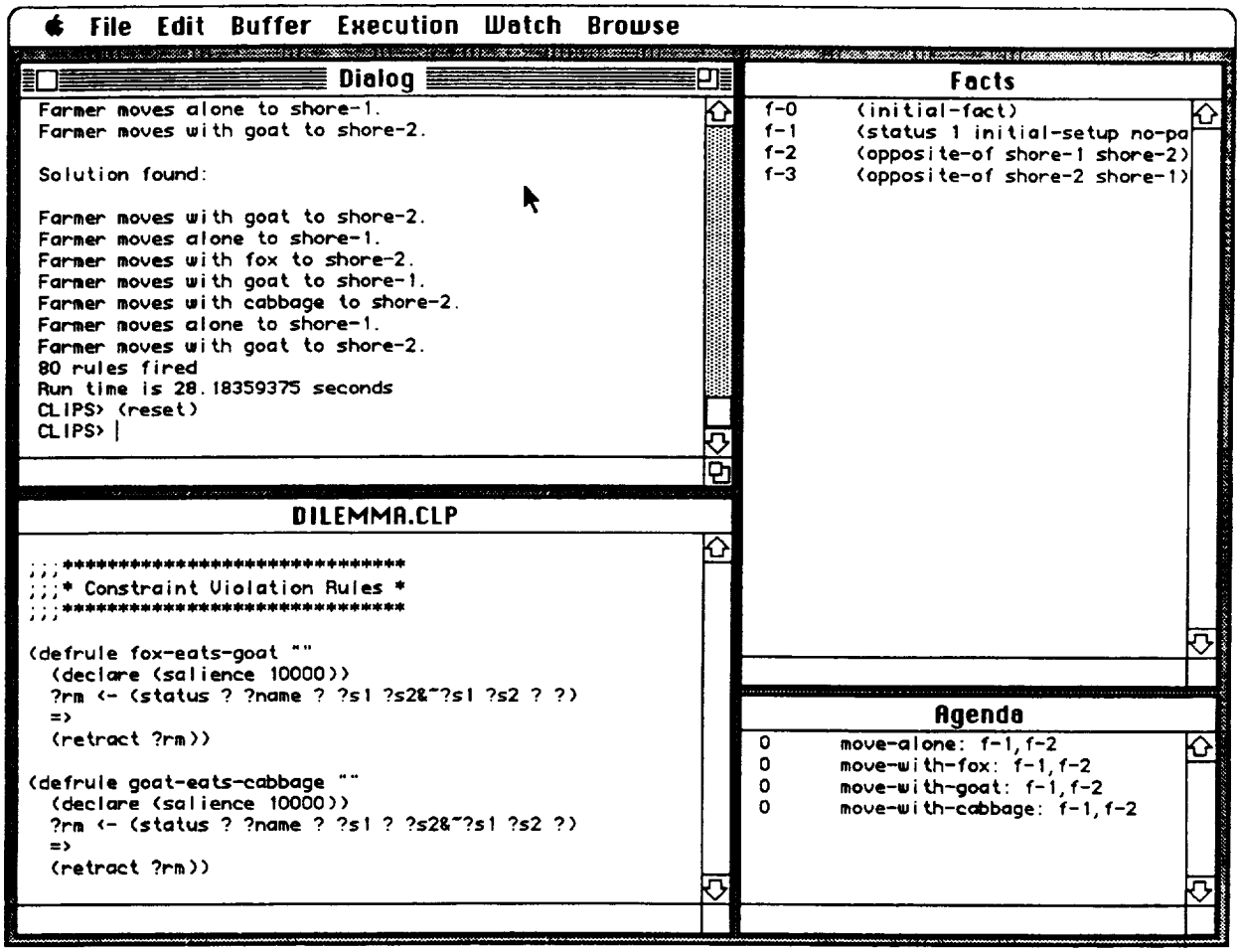
2.2-3 Aids for programming

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
8 Full operational capability (incorporated in production design)

Current Status:
The framework for the tutoring system is complete. The lessons for the basic tutor and advanced tutor have been completed. The tutor is being distributed.

Schedule:
Basic tutoring system: Dec 88
Advanced tutoring system: Apr 89
Distribution of tutor: July 89



190-24 C language integrated production system (CLIPS).

190-24

Title:
C Language Integrated Production System (CLIPS)

Description:
Understand the requirements and technology of expert system tools. Develop an expert system shell to provide low cost tools for training in the use expert system shells for developing and using expert systems, and for providing expert systems for use with computer systems where forward-chaining rules are applicable.

Program: Advanced Programs

Date: Jan 90

Point of Contact: Gary Riley
Telephone: 483-8073
Division: PT - Information Technology
Branch: Software Technology

State: in use

Categories Describing the Work of this Project:

2.2 System design and integration

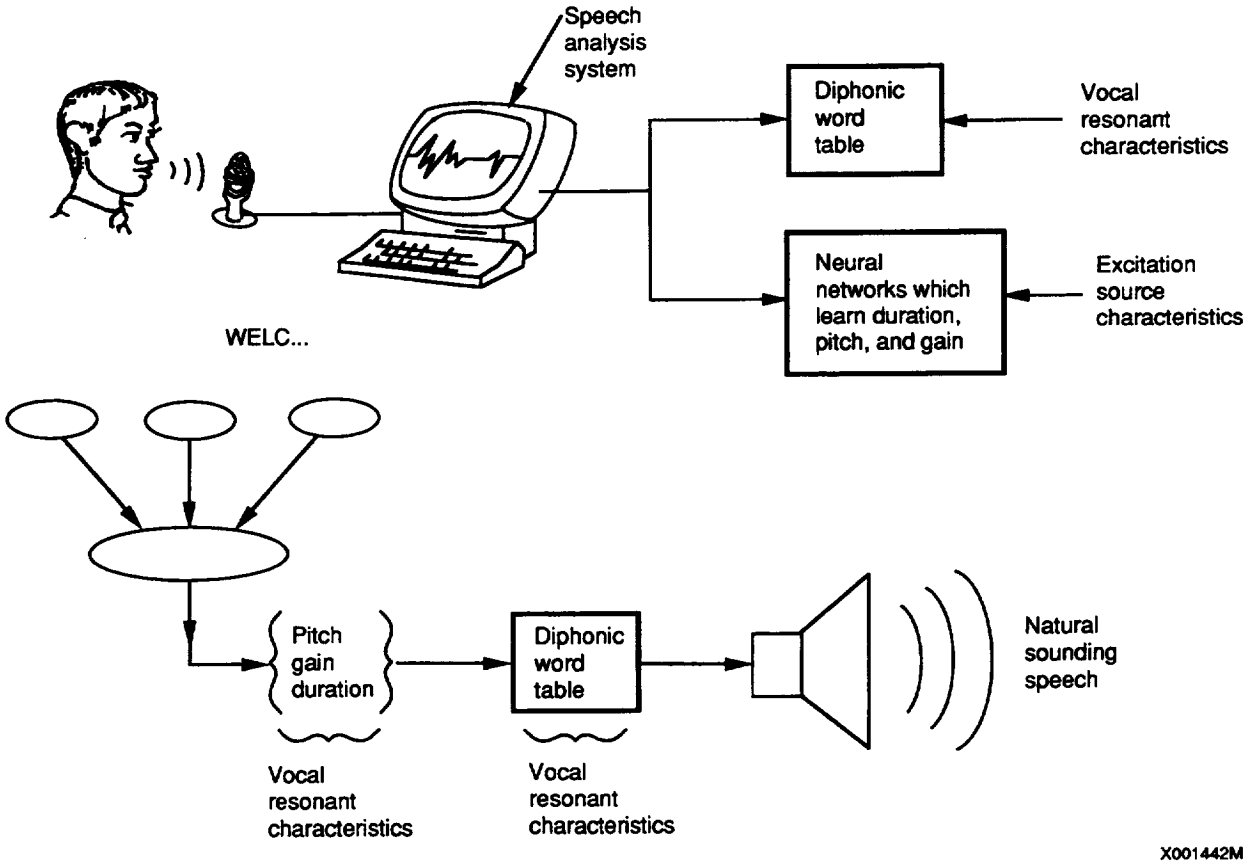
2.2-9 Shells for knowledge based or expert systems

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
8 Full operational capability (incorporated in production design)

Current Status:
Version 2.0, the interactive user interface, and Version 3.0, with enhanced capabilities, were completed in February and September 1986, respectively. Version 4.0, with more enhanced capabilities was completed in March 1987 and Version 4.1 was completed in October 1987.
Version 4.2 was completed in April 1988.
Version 4.3 was completed in June 1989.

Schedule:
Version 3.0, with enhanced capabilities, completed: Sep 86
Version 4.0, with more enhanced capabilities, completed Mar 87
Version 4.1, rule compiler, integrated editor, and on-line help: Oct 87
Version 4.2, code modularization, Macintosh interface: completed Apr 88
Version 4.3, Simple frame system, binary load and save: completed Jun 89
Version 5.0, Object oriented programming language: Jun 90



190-6 AI section/man-machine interfaces.

190-6

Title:
AI Section/Man-Machine Interfaces

Description:
Develop a test bed to integrate natural language processing, input and output using speech. It will use a synthesizer developed in-house that uses neural net technology to produce natural sounding speech.

Program: Shuttle

Date: Dec 90

Point of Contact: James Villarreal

Telephone: 483-8076

Division: PT - Information Technology
Branch: Software Technology

State: Active

Categories Describing the Work of this Project:

1.4 Human-machine interface

1.4-5 Input mechanisms
1.4-13 Voice recognition
1.4-14 Voice synthesis
1.4-10 Processing of natural language

Funded: yes

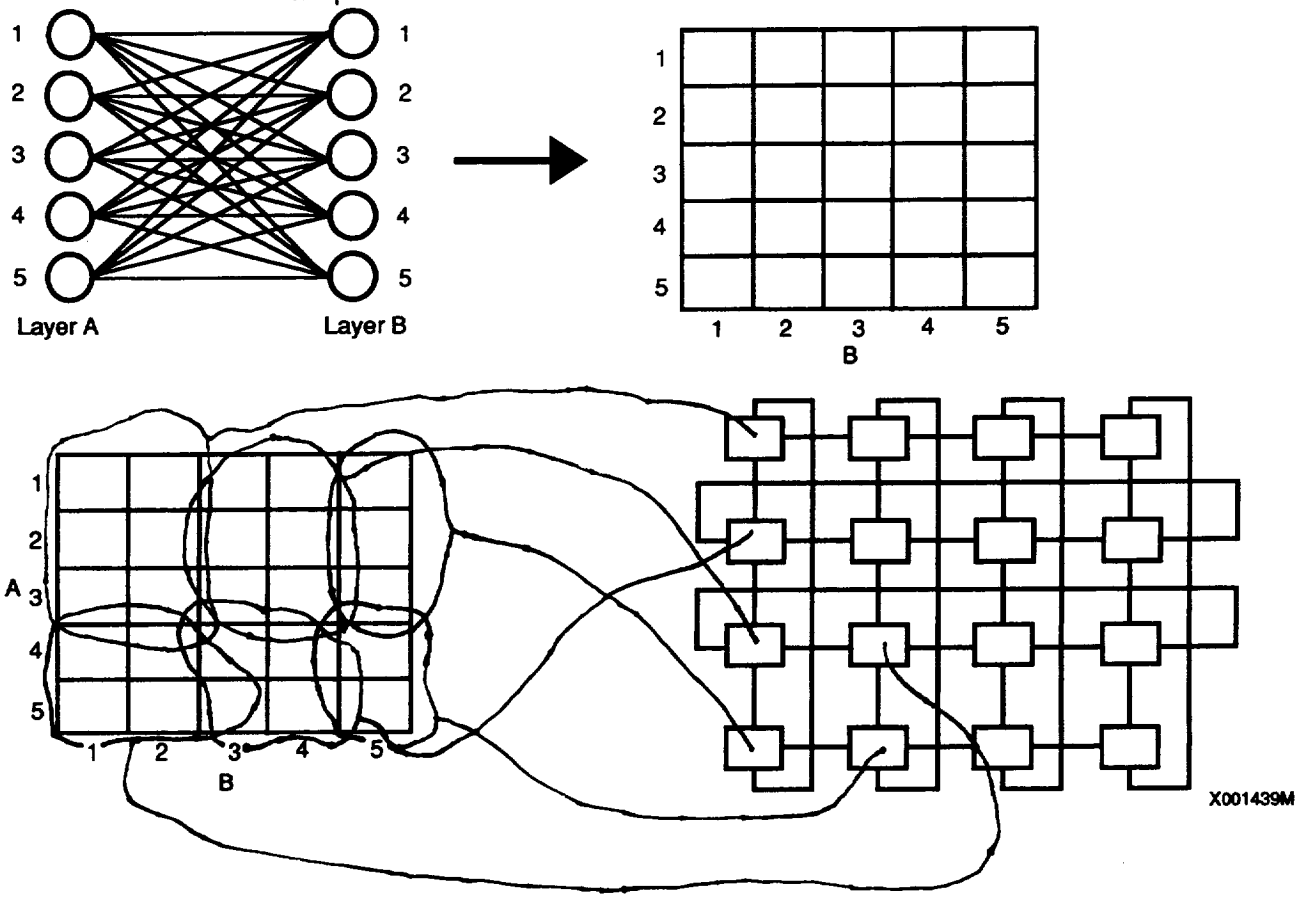
Expected Level of Technology at the End of the Fiscal Year:
5 Component or breadboard tested in the relevant environment

Current Status:
The phoneme synthesizer will be developed when the neural network simulator is completed. A funding source is being sought to assist in support of this effort. Researchers from the University of Pittsburgh have proposed techniques and costs.

Schedule:
Intelligent interface for ESFAS completed: Jan 86
Expert system for circuit diagnosis completed: Oct 86
Work on the phoneme synthesizer has been postponed until the Neural Net simulator is completed.

Multiprocessor artificial
neural system simulator

- Based on INMOS transmi puter: 32 bit - rated at 10 mips and 1 mflops, and 4 bidirectional serial links (xfer rate 10 mbps) which allows one transputer to communicate to 4 other transputer



190-7 Develop neutral network computer system.

190-7

Title:
Develop Neural Network Computer System

Description:
Investigate the use of neural network technology for planning of operations. Implement the hardware and software of a neural network system.

Program: Advanced Programs

Date: Dec 90

Point of Contact: James Villarreal
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8076

State: Active

Categories Describing the Work of this Project:

2.1 Supporting software and hardware

2.1-6 Specialized architecture for artificial intelligence

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
5 Component or breadboard tested in the relevant environment

Current Status:
A Transputer system has been purchased for evaluation. Simulations of neural networks are being developed. Version 1.0 of the transputer neural network simulator will be available in February 1988. The operations manual will be complete in August 89. Procedures for procuring a patent have been started.

Schedule:
Neural net simulator completed: Nov 87
Operations manual completed in December 1989

This page intentionally left blank.

190-80

Title:
Automatic Scheduling Using A Genetic Algorithm Approach

Description:
Use "genetic algorithms" in a program to do automatic scheduling. A wide range of typical scheduling constraints such as employee incompatibilities, shift work, vacation time, etc. will be included.

Program: Advanced Programs

Date: July 89

Point of Contact: Lui Wang
Telephone: 483-8074
Division: PT - Information Technology
Branch: Software Technology

State: Active

Categories Describing the Work of this Project:

1.1 Knowledge

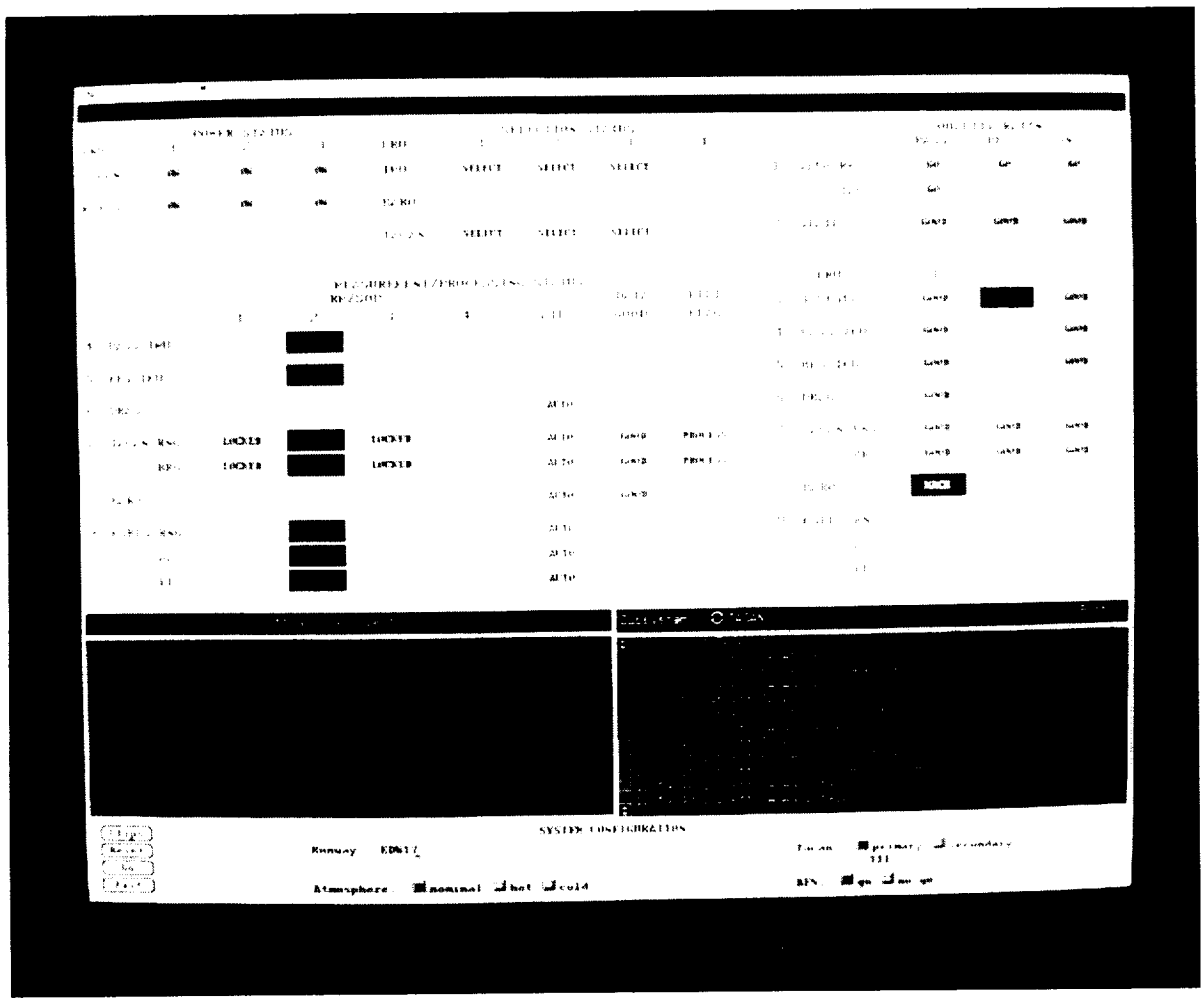
1.1-13 Search techniques

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Current Status:
The design is in the initial phase.

Schedule:
First Prototype: August 1989



190-81 Onboard navigation expert system.

190-81

Title:
On-Board Navigation Expert System

Description:
Develop an expert system for the onboard navigation console that will automate monitoring in real time of onboard hardware and of the status of on board software affecting navigation.

Program: Shuttle

Date: Aug 89

Point of Contact: Lui Wang

Telephone: 483-8074

Division: PT - Information Technology
Branch: Software Technology

State: Active

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems

2.3-9 Monitoring

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
Level not given

Current Status:
The knowledge base for entry and the prototype of the expert system for rendezvous are complete. The knowledge base for rendezvous is being developed. Knowledge for the expert system for ascent and a real time interface for the MCC are complete. The Entry-ONAV will be demonstrated in the MCC operational environment during STS-36. A complete training system for the ONAV console has been is being defined.

Schedule:
Prototype of the entry expert system completed: Apr 87
Entry expert system delivered: Jun 90
Ascent expert system delivered: Oct 91
Deorbit expert system delivered: Mar 91
On orbit and rendezvous expert system delivered: Jun 90

190-29

Title:
An Automatic Assistant for Scheduling and Planning for the Space Station

Description:
Demonstrate that Space Station Freedom activities to be scheduled can be broken into a hierarchy of levels based on criticality, and that scheduling problems can be classified at each hierarchy level to correspond to a set of scheduling rules in an expert system prototype.

Program: SBIR

Date: Jan 5, 1990

Point of Contact: Ervin O'Neal Grice
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8082

State: Active

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems

2.3-12 Scheduling

Funded: no

Expected Level of Technology at the End of the Fiscal Year:

6 Prototype or engineering model tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
Innovative Research, Incorporated	Mohsen Pazirandeh	(303) 321-4917

Current Status:
Phase 1 has been completed.

Schedule:
Demonstration and prototype delivered: August 31, 1989

190-39

Title:
Demonstration of a 3D Vision Algorithm for Space Applications

Description:
Modify algorithms for vision for use in space. Use computer graphics and robot manipulators to demonstrate the algorithms. Deliver software for the algorithms to the MPAD Graphics Laboratory.

Program: Advanced Programs
UPN/PWC: NCC 9-16
Task no.:

Date: Dec 89

Point of Contact: Dr. T. F. Cleghorn
Division: PT - Information Technology
Branch: Software Technology

Telephone: 483-8090

State: Active

Categories Describing the Work of this Project:

2.4 Robotic and telerobotic systems

2.4-3 Computer vision systems

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
LINCOM	Dr. Yashvent Jani	(713) 333-1625
Rice University	Dr. Rui de Figueirido	(713) 527-8101 ext 3569

Current Status:
Software has been delivered to LINCOM. Corrections and modifications to integrate it into the OOS are being made. Removal of software bugs continues following receipt of a revised set of algorithms from the Rice University contractor. Corrections to the Rice software continue to be made. New algorithms have been delivered to replace some of the initial ones.

Schedule:

190-127

Title:
A Neural Network Based Technique for IR Spectral Analysis

Description:
A back propagation network will be used to predict concentrations of certain substances in the IR spectrogram of a sample.

Program: Advanced Programs

Date: Feb 90

Point of Contact: Robert O. Shelton
Telephone: 483-5901
Division: PT - Information Technology
Branch: Software Technology

State: low level

Categories Describing the Work of this Project:

1.2 Sensing
1.1 Knowledge

1.2-2 Coding of sensor information
1.2-14 Visual and optical
1.1-6 Learning

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
5 Component or breadboard tested in the relevant environment

Current Status:

Schedule:

190-128

Title:
A Back Propagation Simulator for the Hypercube

Description:
The Hypercube is a popular parallel computer that supports Concurrent C, Lisp, and Fortran. A simulator that makes efficient use of the parallel capability of the hypercube has been written in C for the back propagation network.

Program: Advanced Programs

Date: Feb 90

Point of Contact: Robert O. Shelton
Telephone: 483-5901
Division: PT - Information Technology
Branch: Software Technology

State: Active

Categories Describing the Work of this Project:

2.1 Supporting software and hardware
1.1 Knowledge

2.1-2 Distributed systems
1.1-6 Learning

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Current Status:

Schedule:

190-140

Title:
Correlation-Based Synthetic discriminate Filter for Image Segmentation

Description:
Image segmentation is used in machine vision to extract an object of interest from a noisy or cluttered field of view. The correlation SDF (Synthetic discriminate Filter) is a method of image segmentation based on linear algebra. A version of this algorithm that performs correlations using discrete Fourier transforms has been written in C.

Program: Advanced Programs

Date: April 90

Point of Contact: Robert O. Shelton
Telephone: 483-5901
Division: PT - Information Technology
Branch: Software Technology

State: Active

Categories Describing the Work of this Project:

2.4 Robotic and telerobotic systems
1.1 Knowledge
1.2 Sensing

2.4-2 Automatic inspection
2.4-3 Computer vision systems
2.4-7 Retrieval and rescue
1.1-11 Recognition of objects
1.1-14 Simulation

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Current Status:

Schedule:

190-141

Title:
An Accelerated Method for Back Propagation Networks

Description:
The back propagation network is an extremely popular neural network that has been applied successfully to modeling problems ranging from predicting sun spots to synthesizing speech. The biggest limitation of this network is the computational intensive training algorithm. In some cases, the new training algorithm can be two orders of magnitude faster than the standard method. A patent application has been filed.

Program: Advanced Programs

Date: April 90

Point of Contact: Robert O. Shelton
Telephone: 483-5901
Division: PT - Information Technology
Branch: Software Technology

State: Active

Categories Describing the Work of this Project:

1.1 Knowledge
2.2 System design and integration

1.1-6 Learning
2.2-3 Aids for programming

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Current Status:

Schedule:

190-142

Title:
Fuzzy Ring Network for Machine Vision

Description:
A prototype vision system has been produced that can recognize objects independent of rotation, translation, and scale. The system also estimates the orientation of the object recognized. The current system will be tested further, and an image segmentation capability will be added.

Program: Advanced Programs

Date: July 89

Point of Contact: Robert O. Shelton
Telephone: 483-5901
Division: PT - Information Technology
Branch: Software Technology

State: Active

Categories Describing the Work of this Project:

2.4 Robotic and telerobotic systems
1.1 Knowledge
1.2 Sensing

2.4-2 Automatic inspection
2.4-3 Computer vision systems
2.4-7 Retrieval and rescue
1.1-11 Recognition of objects
1.2-14 Visual and optical

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Current Status:

Schedule:

190-143

Title:
A Difference Optimized Training Scheme for the Neocognitron

Description:
The Neocognitron is a neural network used for machine vision. The difference optimized training scheme provides an accelerated training capability for the Neocognitron. A patent application has been filed.

Program: Advanced Programs

Date: Apr 90

Point of Contact: Robert O. Shelton
Telephone: 483-5901
Division: PT - Information Technology
Branch: Software Technology

State: low level

Categories Describing the Work of this Project:

2.4 Robotic and telerobotic systems
1.1 Knowledge
1.2 Sensing

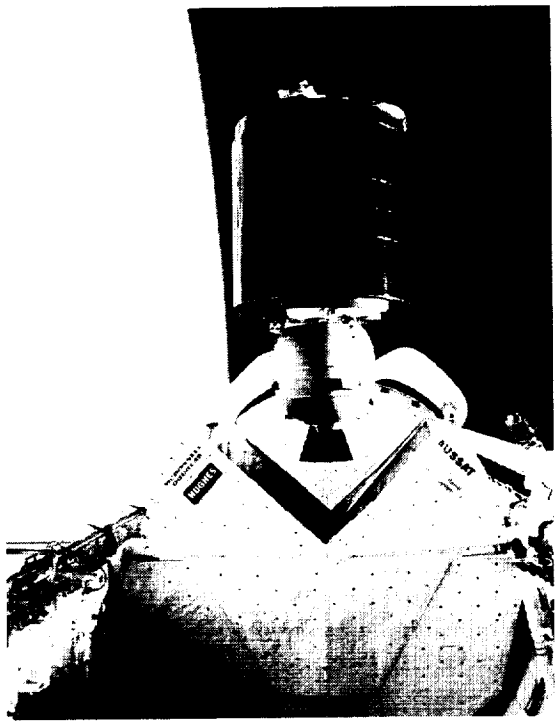
2.4-2 Automatic inspection
2.4-3 Computer vision systems
2.4-7 Retrieval and rescue
1.1-6 Learning
1.1-11 Recognition of objects
1.2-14 Visual and optical

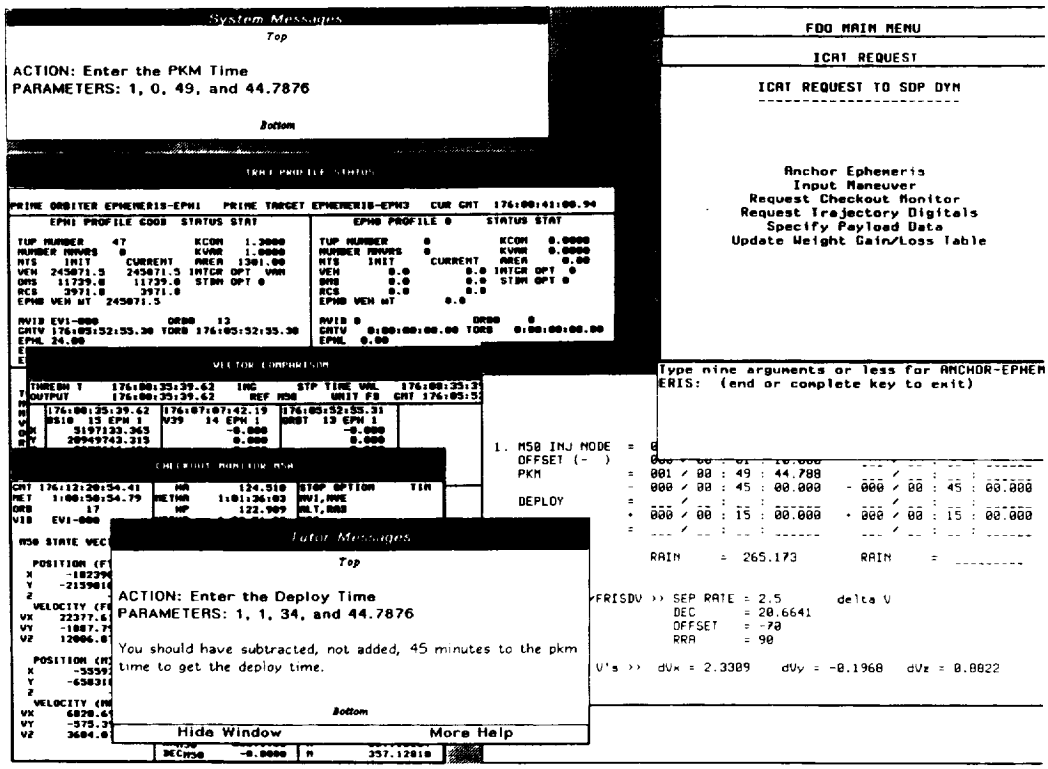
Funded: no

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Current Status:
Continues at a low level of effort.

Schedule:





190-57 Intelligent computer-aided training system for PAM deploys.

190-157

Title:
Intelligent Computer-Aided Training System for PAM Deploys

Description:
Design a system to use in training flight dynamics officers in the development of payloads that will use the payload assist module. The system is to be delivered to the Orbit Design Section of the Flight Design and Dynamics Division for use in training FDOS.

Program: Artificial Intelligence

Date: January 1990

Point of Contact: Lui Wang
Telephone: 483-8074
Division: PT - Information Technology
Branch: Software Technology

State: in 190-79

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems
1.1 Knowledge
1.4 Human-machine interface

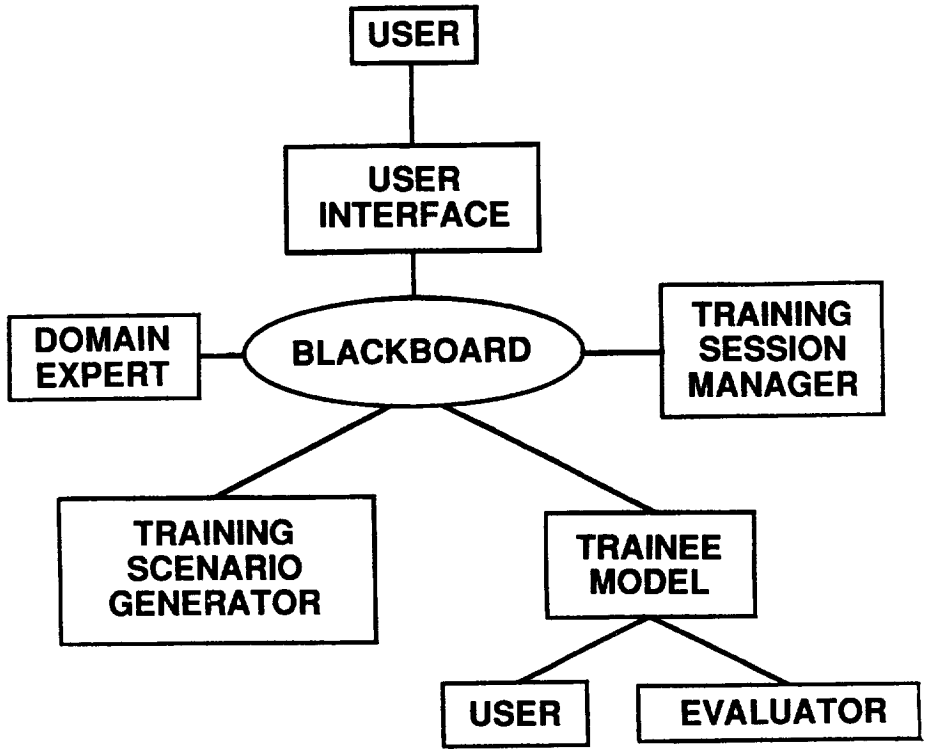
2.3-1 Control
2.3-4 Engineering support
2.3-7 Interacting expert systems
1.1-14 Simulation
1.4-6 Interfaces to knowledge based or expert systems
1.4-13 Voice recognition

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
8 Full operational capability (incorporated in production design)

Current Status:
This project is included in 190-79.

Schedule:
Completion of a prototype to be used for evaluating the system: Jun 87
Delivery of the final product: Dec 89



190-158 Intelligent computer-aided training (ICAT).

190-158

Title:
Intelligent Computer-Aided Training (ICAT)

Description:
Develop autonomous intelligent systems for teaching complex procedural tasks; create a software environment to facilitate development of ICAT systems. Systems being developed are ICAT systems for Instrument Pointing System (IPS) (for Spacelab training at JSC & MSFC) and Main Propulsion Pneumatics (MMP) (for training system engineers at KSC), and intelligent tutoring systems for high school physics and CLIPS.

Program: Shuttle

Date: January 1990

Point of Contact: Robert T. Savely
Telephone: 483-8105
Division: PT - Information Technology
Branch: Software Technology

State: in 190-79

Categories Describing the Work of this Project:

2.2 System design and integration
2.3 Knowledge based or expert systems
1.1 Knowledge
1.4 Human-machine interface

2.2-3 Aids for programming
2.2-8 Knowledge engineering
2.2-9 Shells for knowledge based or expert systems
2.3-7 Interacting expert systems
1.1-12 Representation and reasoning
1.4-6 Interfaces to knowledge based or expert systems

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
2 Conceptual design formulated

Current Status:
This project is included in 190-79.

Schedule:
Projects are ongoing.

190-3

Title:
Neural Network Simulation on Class VI Computers

Description:
Size the Sejnowski Neural Network for convergence. Apply the technology developed to other neural networks. This project supports other projects in which neural networks are coded on parallel processing machines.

Program: Advanced Programs

Date: Jan 90

Point of Contact: Robert O. Shelton
Telephone: 483-5901
Division: PT - Information Technology
Branch: Software Technology

State: low level

Categories Describing the Work of this Project:

1.1 Knowledge

1.1-6 Learning
1.1-9 Planning

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
3 Conceptual design tested

Current Status:
The project was completed and the program submitted to COSMIC in July 1989. Two JSC internal notes, 89-FM6 and 89-FM7, were published. Work is continuing at a low level of effort.

Schedule:
Test the Sejnowski network with 100 hidden nodes: Mar 87
Test the Sejnowski network with 150 hidden nodes: Apr 87
Test the Sejnowski network with 300 hidden nodes: May 87
Test the Sejnowski network with 500 hidden nodes: Dec 87

190-33

Title:
Robot Path Planning Using Genetic Algorithms

Description:
A program has been written using a genetic algorithm to determine good paths for robot manipulators. Mobile robots and end effectors are included.

Program: Advanced Programs

Date: Dec 89

Point of Contact: Dr. T. F.Cleghorn

Telephone: 483-8090

Division: PT - Information Technology
Branch: Software Technology

State: Active

Categories Describing the Work of this Project:

1.3 Actuation and manipulation

1.3-3 Collision avoidance

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Current Status:
The algorithm has been defined and the software written in Lisp. The optimum configuration for the input data has been determined. Papers have been presented at conferences on AI and robotics. Plans for the coming year include building a genetic algorithm system that is modular and adaptable to various problems. C will be used instead of Lisp for portability and ease of use.

Schedule:
Start of program: Jan 88
Phase I analysis – mobile vehicles: Jun 88
Phase II analysis – joint angle problem: Dec 88
Work continues with emphasis on mobile arms for the Space Station and control of joint angles.

190-35

Title:
Greyscale Morphology in Machine Vision

Description:
Use greyscale morphology in creating an Artificial Intelligence system that will construct synthetic views of a structure from a CAD data base. As the CAD data base is updated, the AI system will propagate the visible effect of the changes throughout to the final view. The ability to synthesize views will be useful in matching vision systems using digital and optical correlation.

Program: Small Business Innovative Research Date: Dec 89

Point of Contact: Dr. T. F. Cleghorn Telephone: 483-8090
Division: PT - Information Technology
Branch: Software Technology

State: completed

Categories Describing the Work of this Project:

2.4 Robotic and telerobotic systems

2.4-3 Computer vision systems

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Current Status:
Software received from Machine Vision, International in April 1989 consisted of code and demonstrations of an algorithm for using machine vision techniques to perform autonomous rendezvous. The algorithms can also be used to determine the state properties of a target satellite. All products have been delivered -- The contract is complete.

Schedule:
A Phase II contract was let to Machine Vision, International, Ann Arbor, Michigan in March 1987 Final report, August 1989.

190-37

Title:
The Use of Fuzzy Set Theory in Controlling Failures in Space Systems

Description:
Develop and evaluate fuzzy sets for managing failures in guidance, navigation, and control of space vehicles. Explore decision criteria for control, system reconfiguration, and management of redundancies. Use analysis and simulation to study the sensitivity of the failure detection system to imperfections in the model and the imprecision of data when the system operates in real time.

Program: Shuttle

Date: Dec 89

Point of Contact: Dr. T. F Cleghorn
Telephone: 483-8090
Division: PT - Information Technology
Branch: Software Technology

State: completed

Categories Describing the Work of this Project:

1.1 Knowledge

1.1-10 Problem solving

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Current Status:
A fuzzy control system was demonstrated at JSC in January 1989, and the revised code delivered in May 1989. The fuzzy control system is being integrated into the Robotics Software Testbed. The project is basically completed. -- Professor Sheridan is on a sabbatical and his graduate student has nearly finished writing his thesis.

Schedule:
Initiation of the contract: Jan 87
Phase I analysis complete: Jul 87
Phase II analysis and simulation complete: Dec 87
Demonstration of sensitivity analysis using the simulation: Jan 89
Final report completed: Dec 89

190-4

Title:
NETS: A Tool for the Development and Delivery of Neural Networks

Description:
NETS is a programming tool for building neural networks. There are currently over 70 users in the U.S. government. NETS has been delivered to COSMIC for general distribution; sales are scheduled for July, 1989. Version 2.0 of NETS is targeted for release in mid-August, 1989. Version 2.0 will allow users to embed their networks in other systems.

Program: Advanced Programs

Date: Dec 90

Point of Contact: Robert O. Shelton
Telephone: 483-5901
Division: PT - Information Technology
Branch: Software Technology

State: low level

Categories Describing the Work of this Project:

1.1 Knowledge
2.1 Supporting software and hardware
2.2 System design and integration

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
8 Full operational capability (incorporated in production design)

Current Status:
The programs are being maintained.

Schedule:
Version 2.0 beta release: July 1989
Version 2.0 formal release: August 1989

190-49

Title:
Resource Planning and Management Expert System

Description:
Develop an expert system that will allow users to schedule events, define precedence relations between events, and identify resources with events.

Program: Advanced Programs

Date: July 89

Point of Contact: Robert T. Savely
Telephone: 483-8105
Division: PT - Information Technology
Branch: Software Technology

State: discontinued

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems

2.3-12 Scheduling

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Current Status:
The task is inactive.

Schedule:
This task has been discontinued.

190-5

Title:
Spatiotemporal Neural Network Systems

Description:
Neural networks are especially useful for categorizing or generalizing from a given data set. Conventional neural networks operate on static data. The Spatiotemporal Neural Network incorporates adaptive digital filtering methods with neural networks to operate on sequences or time dependent data. A practical application could include defining the interrelationships between sensors that vary over time.

Program: Advanced Programs

Date: January 8, 1990

Point of Contact James Villarreal
Telephone: 483-8076
Division: PT - Information Technology
Branch: Software Technology

State: Active

Categories Describing the Work of this Project:

1.1 Knowledge

1.1-6 Learning
1.1-13 Search techniques
1.1-12 Representation and reasoning
1.1-7 Monitoring
1.1-2 Control methods
1.1-10 Problem solving

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Current Status:
A neural network incorporating Finite Impulse Response filters in the weighting structures has been developed and tested. Efforts are underway to distribute this tool to COSMIC. An Infinite Impulse Response filtering technique is being developed.

Schedule:
July 23, 1989: Replacement of weights in a standard back propagation network with digital filters is conceived.
August 1, 1989: Code is developed to adapt the weights in a single filter.
August 21, 1989: An operable filter (both poles and zeros) replacing the weights in a standard back propagation network is developed.

190-50

Title:
Autonomous Object Recognition for the EVA Retriever

Description:
Determine the viability of using Neural Networks for recognizing objects and determining their orientation in the EVA Retriever project. The capabilities of the method will be demonstrated with a prototype system.

Program: Advanced Programs Date: Jan 90

Point of Contact: James Villarreal Telephone: 483-8076
Division: PT - Information Technology
Branch: Software Technology

State: inactive

Categories Describing the Work of this Project:

2.4 Robotic and telerobotic systems

2.4-3 Computer vision systems

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Current Status:
A tool for evaluating neural networks has been delivered.

Schedule:

190-54

Title:
Space Station Mission Requirements Data Bases

Description:
Develop a prototype of a graphical front-end for the Mission Requirements data base, with an expert system to schedule space station missions. Use a graphical timeline of Space Station missions to provide data access and scheduling.

Program: Space Station

Date: Jan 90

Point of Contact: Robert T. Savely
Telephone: 483-8105
Division: PT - Information Technology
Branch: Software Technology

State: inactive

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems

2.3-12 Scheduling

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
3 Conceptual design tested

Current Status:
The task is inactive.

Schedule:
The task is inactive.

190-55

Title:
Expert System for Shuttle Electrical Power Management

Description:
Provide an automated aid to schedule activity blocks from which existing software can derive power profiles.

Program: Shuttle

Date: Jan 90

Point of Contact: Robert T. Savely
Telephone: 483-8105
Division: PT - Information Technology
Branch: Software Technology

State: inactive

Categories Describing the Work of this Project:

2.3 Knowledge based or expert systems

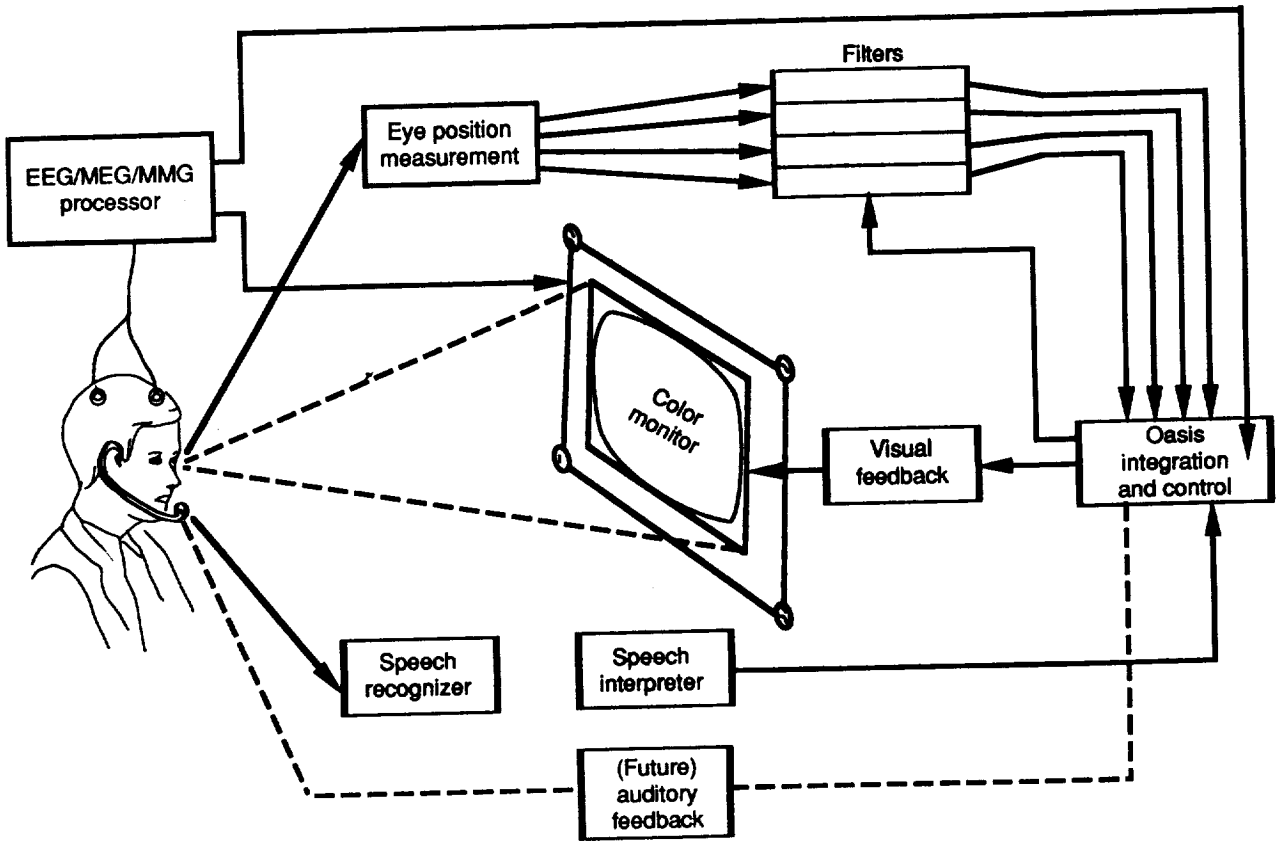
2.3-12 Scheduling

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
3 Conceptual design tested

Current Status:
The task is inactive.

Schedule:
The task is inactive.



190-8 Development and experimentation of eye/brain/task testbed.

190-8

Title:
Development and Experimentation of Eye/Brain/Task Test Bed

Description:
Assess the technology for sensing brain waves from the perspective of an overall system. Develop a prototype of a laboratory test bed, and conduct pilot experiments to determine system response and demonstrate the utility of the test bed in developing applications of the linkage of eye, brain, and task.

Program: Advanced Programs

Date: Dec 90

Point of Contact: James Villarreal
Telephone: 483-8076
Division: PT - Information Technology
Branch: Software Technology

State: completed

Categories Describing the Work of this Project:

1.4 Human-machine interface

1.4-1 Controls

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Current Status:
It is anticipated that Phase II will start in May 1987.
The testbed has been completed – Data analysis is starting. The AI Section will work closely with Analytics during the analysis. Neural networks will be used for determining variations in alpha, beta, and eye movements.

Schedule:
Proposal for Phase I submitted: Jun 85
Report on completion of Phase I: Jul 86
Eye, brain, task test bed completed: Feb 88
Pilot studies completed: Jun 88
Demonstration of eye, brain, task test bed: Dec 88
Final report received: Dec 89

This page intentionally left blank.

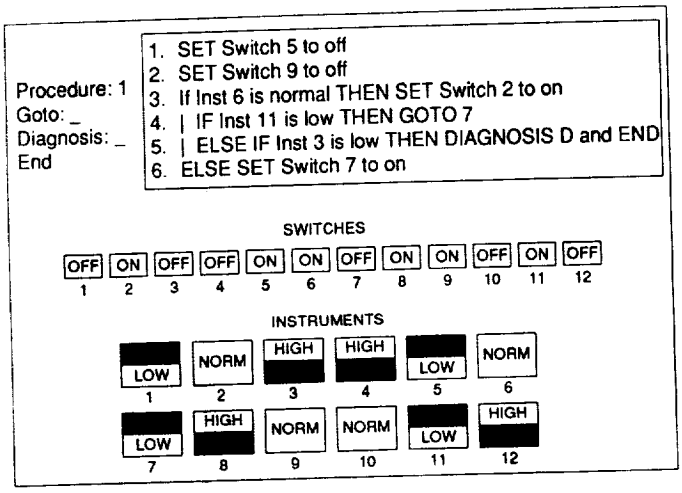
PROJECTS REPORTED BY SP - MAN-SYSTEMS DIVISION

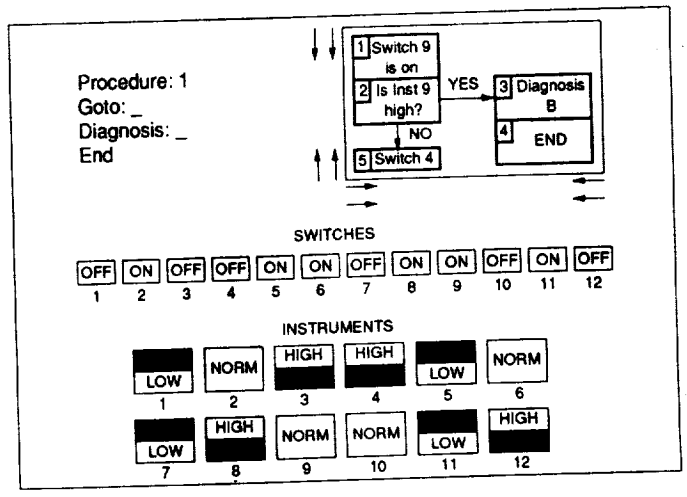
Category:	Projects
1.1 Knowledge	1
1.4 Human-Machine Interface	5
2.2 System Design and Integration	1

Level of Technological Readiness at the End of FY90	Projects
1 Basic Principle Observed or Reported	1
3 Conceptual Design Tested	1
4 Critical Function or Characteristic Demonstrated	3
6 Prototype or Engineering Model Tested in the Relevant Environment	2

Number of Projects 7

Title	Number	Page
Biodynamic Checklist Processing	190-15	254
Interface to Advanced Display, Control, and Computer Technologies	190-13	253
Man and Robot Motion Modeling	190-19	259
Operator Cognitive Modeling	190-18	257
Space Station Program Human-Computer Interface Guide and Standards	190-16	255
Space Station Workstation System	190-17	256
Telerobotic Servicer Man-Systems Integration and Testing	190-14	261





190-13 Interface of advanced display, control, and computer technologies.

190-13

Title:
Interface to Advanced Display, Control, and Computer Technologies

Description:
Examine the interaction of the user with advanced technologies for display, control, and computers, to optimize the interface between the user and the system in work stations for spacecraft. Data on human performance are gathered; reports detail the interaction of the operator and system; and proposed interfaces are demonstrated.

Program: OAST RTOP
UPN/PWC: 506-47-11-02

Date: Jan 90

Point of Contact: Marianne Rudisill, Ph.D.
Division: SP - Man-Systems
Branch: Crew Station
Section: Crew Interface Analysis

Telephone: 483-3706

State: Active

Categories Describing the Work of this Project:

1.4 Human-machine interface

1.4-1 Controls
1.4-2 Displays
1.4-5 Input mechanisms
1.4-6 Interfaces to knowledge based or expert systems
1.4-7 Management of user interfaces

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
1 Basic principle observed or reported

Performing Organizations	Name of Contact	Telephone
Lockheed Engineering & Sciences Company	Timothy D. McKay, Ph.D.	(713) 333-6827

Current Status:
The prototype for electronic display of procedures is being designed and developed. Three NASA technical reports are complete: Levels of Detail in Expert System Explanations; Designers Models of the Human- Computer Interface; and How does Fitts' Law Fit Pointing and Dragging. Research continued on coding display information and on naive physics. Started a new program investigating interfaces to intelligent systems.

Schedule:
Attachment to the Data Management System Test Bed: Jul 87
Electronic display of procedural information: Jun 87; Feb 88; Mar 89
Symbols and icons: Oct 87, Apr 88, Feb 89, Apr 89
Develop tools for cognitive modeling: Oct 87
Evaluate controls for direct manipulation in 1g and 0g: Mar 88, Dec 88-Jan 89, Sep 89

190-15

Title:
Biodynamic Checklist Processing

Description:
Develop an expert system to evaluate proposed tasks. Candidate tasks in the natural language format of the Flight Data Files will be evaluated using animated anthropomorphic and bio-dynamic models of humans and graphical representations of workplaces. The expert system will use multiple levels of reasoning about the tasks, environment, and capabilities.

Program: OSSA RTOP
NASA Headquarters Program Code: E
UPN/PWC: 199-06-11-25

Date: Jan 90

Point of Contact: Barbara Woolford
Division: SP - Man-Systems
Branch: Crew Station
Section: Crew Interface Analysis

Telephone: 483-3701

State: Active

Categories Describing the Work of this Project:

1.4 Human-machine interface
1.1 Knowledge

1.4-6 Interfaces to knowledge based or expert systems
1.4-10 Processing of natural language
1.1-9 Planning

Funded: yes

Expected Level of Technology at the End of the Fiscal Year: 6 Prototype or engineering model tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
University of Pennsylvania	Norman Badler	(215) 898-5862

Current Status:
Algorithms for generating motion between key positions have been improved. Capability to deal with time and duration (e.g. "while A", "until B", "for x minutes") has been added. Demonstrations have been started of moving the entire body to perform a task.

Schedule:
Extension of whole body translation: Winter 1990
Expansion of vocabulary: Spring 1991
Extension of hierarchical reasoning: Summer 1991

190-16

Title:
Space Station Program Human-Computer Interface Guide and Standards

Description:
Develop and document a standard design for Human-Computer Interface for information systems in the Space Station Program. Include standards and guidelines for menus, icons, windowing functions, use of color, highlighting, data entry, and functional grouping. Develop prototype interfaces for evaluation in an operational workstation. Develop and document a standard human-computer interface for the Space Station.

Program: Space Station

Date: Jan 90

Point of Contact: Marianne Rudisill, Ph.D.
Telephone: 483-3706
Division: SP - Man-Systems
Branch: Crew Station
Section: Crew Interface Analysis

State: Active

Categories Describing the Work of this Project:

1.4 Human-machine interface
2.2 System design and integration

1.4-1 Controls
1.4-2 Display
1.4-7 Management of user interfaces
2.2-2 Aids for design

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Performing Organizations	Name of Contact	Telephone
Lockheed Engineering & Sciences Company	Timothy D. McKay, Ph.D.	(713) 333-6827

Current Status:
Generated and reviewed a series of prototypes in a 6-week long tiger team effort with McDonnell Douglas. Identified a number of functional requirements for the Space Station User Support Environment (USE) after three iterations of prototypes. Reviewed the User Interface Requirements document (SY45) and the USE Software Requirements Specification in preparation for the Data Management System Preliminary Design Review.

Schedule:
Develop a prototype of the interface: Start in Jul 87
Complete the preliminary guide to the use of the interface: Oct 87
Baseline a guidelines document for use in the Space Station Program: Jan 89
Standards: Begin development, Jan 89; first draft, Jul 89; 2nd draft, Oct 89; 3rd draft, Feb/Mar 90; final standards, April/May 90.

190-17

Title:
Space Station Workstation System

Description:
Develop and evaluate ideas for the Space Station workstation system, and for individual workstations, (e.g.: command and control; payload and experiment operations). Fabricate operating workstations; integrate them into a man-systems testbed and interface them to the data management system testbed. Chair and support the program-wide Space Station Work–station System Integration Group.

Program: Space Station

Date: Jan 90

Point of Contact: Dean Jensen, Ph.D.

Telephone: 438-4798

Division: SP - Man-Systems
Branch: Crew Station
Section: Crew Interface Analysis

State: Active

Categories Describing the Work of this Project:

1.4 Human-machine interface
2.2 System design and integration

1.4-1 Controls
1.4-2 Displays
1.4-3 Feedback of force and torque
2.2-8 Knowledge engineering

Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Performing Organizations	Name of Contact	Telephone
Lockheed Engineering & Sciences Company	S. Adam	(713) 333-6608

Current Status:
Concepts for command and control and cupola workstations are being evaluated. The Requirements Document for the Space Station Integrated Workstation System is stored in a data base. Workstations will be evaluated and the number and locations needed will be assessed using a data base of information on workstation tasks. Configurations of hand controllers for robotics and free flyers will be determined.

Schedule:
Evaluation of workstations: Began in May 89; will iterate through the CDR.
Compile data on tasks for the workstations: Began April 1989
Recommendations of number and locations of workstations: October 1989
Hand controller commonality study: Began June 1989
Recommendations of configurations of hand controllers: June 1990

190-18

Title:
Operator Cognitive Modeling

Description:
Automate collection of expert knowledge with a Knowledge Acquisition and Representation Toolkit (KART). Develop methods and tools for cognitive models of humans engaged in operations in space. Use the information in advanced human-machine interfaces and guidelines for architectures of intelligent systems. Use machine intelligence (neural networks, for example) to model natural intelligence.

Program: OAST Pathfinder
NASA Headquarters Program Code: RC

Date: Jan 90

Point of Contact: Marianne Rudisill, Ph.D.
Division: SP - Man-Systems
Branch: Crew Station
Section: Crew Interface Analysis

Telephone: 483-3706

State: Active

Categories Describing the Work of this Project:

1.1 Knowledge
1.4 Human-machine interface

1.1-1 Acquisition of knowledge
1.1-12 Representation and reasoning
1.1-14 Simulation
1.4-6 Interfaces to knowledge based or expert systems

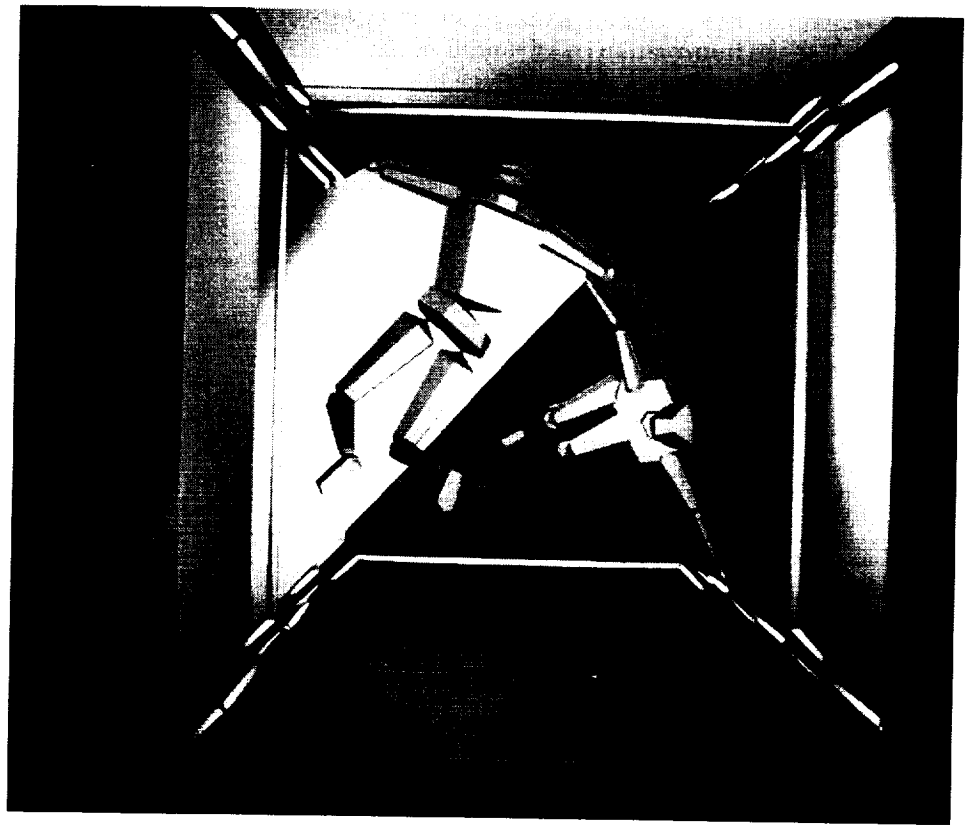
Funded: yes

Expected Level of Technology at the End of the Fiscal Year:
4 Critical function or characteristic demonstrated

Performing Organizations	Name of Contact	Telephone
Lockheed Engineering & Sciences Company	Timothy D. McKay, Ph.D.	(713) 333-6827

Current Status:
Classification taxonomies were developed for both advanced information technologies and crew tasks. A commercial data base was selected for storing information gathered on crew tasks and information technologies. A preliminary paper on operator modeling was drafted. Development continued on a toolkit for knowledge acquisition and representation.

Schedule:



190-19 Man and robot motion modeling.

190-19

Title:
Man and Robot Motion Modeling

Description:
Use spring and damper models of joints with multiple degrees of freedom and appropriate limits of motion in developing models of kinematic and dynamic forces and motions of humans and robots. Provide outputs such as still pictures and animation for ease in understanding the results of the analyses. Validate the computer models by comparing the graphics output of the computer program with empirical data.

Program: OSSA, OAST
NASA Headquarters Program Code: EB, RC
UPN/PWC: 199-06-11-21 506-47-11-03

Date: Jan 90

Point of Contact: Linda S. Orr
Division: SP - Man-Systems
Branch: Crew Station
Section: Crew Interface Analysis

Telephone: 483-3722

State: in use

Categories Describing the Work of this Project:

2.2 System design and integration

2.2-2 Aids for design
2.2-6 Automation of engineering
2.2-5 Automatic checkout and test
2.2-10 Validation and verification

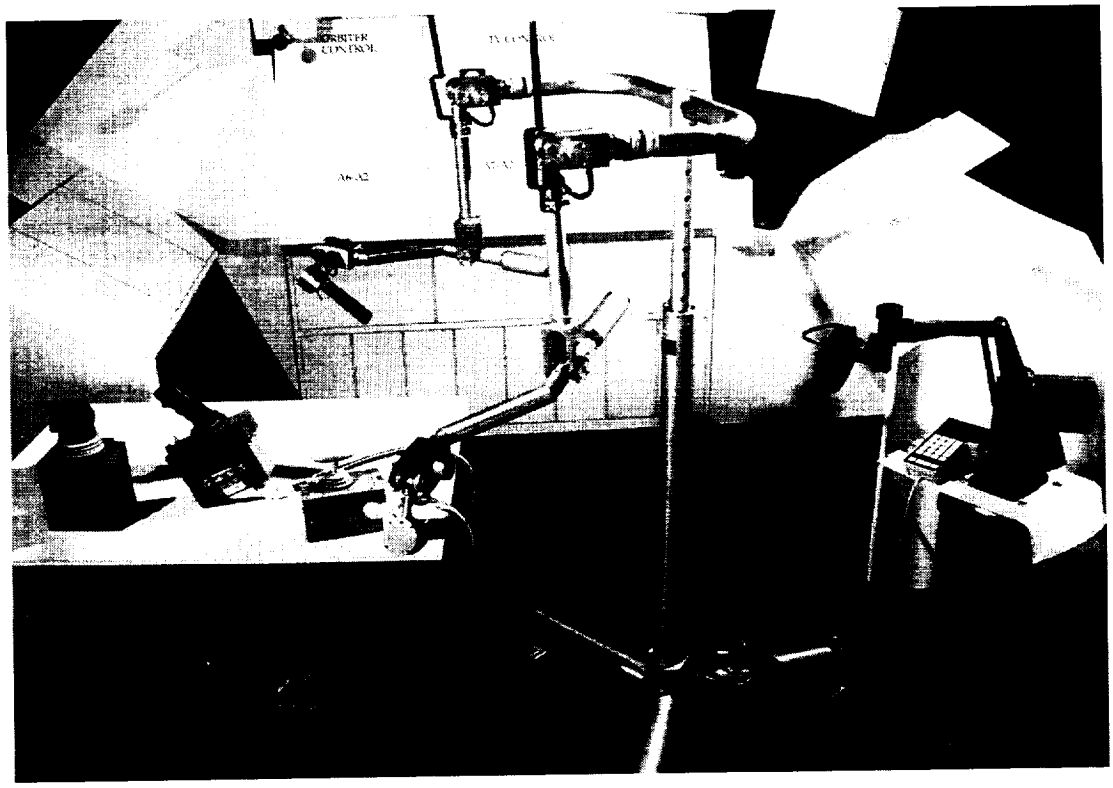
Funded: yes

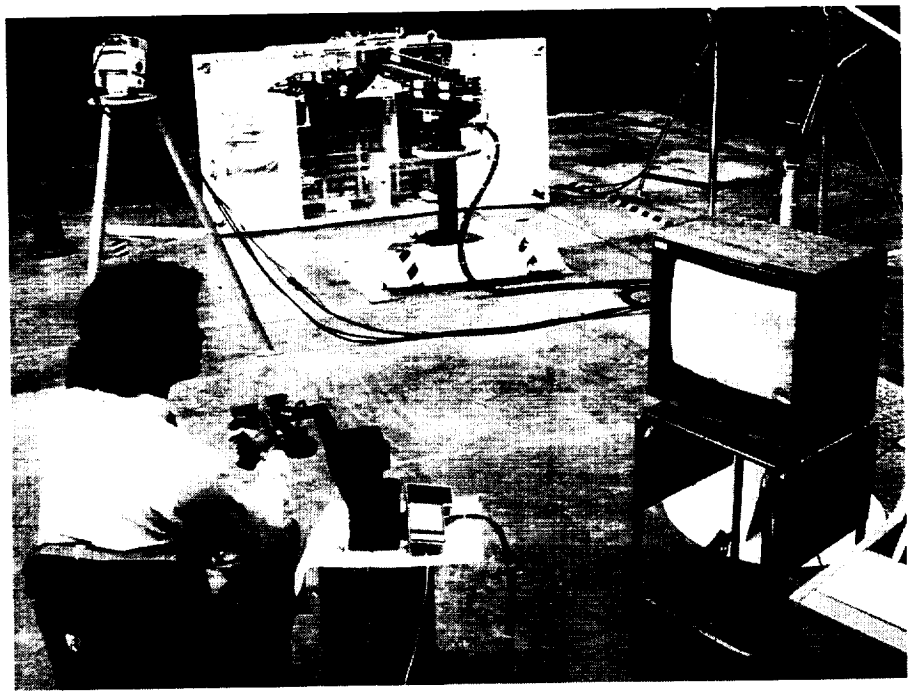
Expected Level of Technology at the End of the Fiscal Year:
6 Prototype or engineering model tested in the relevant environment

Performing Organizations	Name of Contact	Telephone
University of Pennsylvania	Norman Badler	(215) 898-5862
Lockheed Engineering & Sciences Company	Edmund Khouri	713) 483-3616

Current Status:
Kinematic models are complete and in use. The force model has been demonstrated with a Puma robotic arm. The capability exists for output in graphic form. Data is being collected for use in evaluating the model. The user interface requires work to make it more user-friendly. The dynamic program is useable but hard to set up at present.

Schedule:
The dynamics model was installed is November 1988.
Empirical data will be collected throughout FY89.
The user interface is being improved for set-up of dynamic simulations, and should be complete in the fall of 1989





190-14 Telerobotic servicer man-systems integration and testing.

190-14

Title:
Telerobotic Servicer Man-Systems Integration and Testing

Description:
Develop requirements and guidelines that support integration of humans with the Flight Telerobotic Servicer (FTS); use human engineering in design and verification of interfaces. Design tests to optimize human interactions with the FTS system; perform tests with man in the loop. Assess designs for display and control devices, work stations, and operator aids.

Program: Flight Telerobotic Servicer
UPN/PWC: 486-41 486-12

Date: Dec 90

Point of Contact: Jay Legendre
Division: SP - Man-Systems
Branch: Crew Station
Section: Crew Interface Analysis

Telephone: 483-3697

State: discontinued

Categories Describing the Work of this Project:

1.4 Human-machine interface
2.2 System design and integration
2.4 Robotic and telerobotic systems

1.4-1 Controls
1.4-2 Displays
1.4-12 Tradeoffs for automation
2.2-10 Validation and verification
2.4-6 Servicing and repair

Funded: no

Expected Level of Technology at the End of the Fiscal Year:
3 Conceptual design tested

Current Status:
The project has been terminated.

Schedule:
NASA Technical Reports: Programmable Display Pushbuttons, Feb 89; Gray Scale Values, April 89; FTS Illumination Requirements, April 89; Displaced Visual Feedback, April 89; Voice Commanded Systems, June 89; Chapter submitted for Man Systems Integration Standards (MSIS); Human-Telerobot Interface: Feb 89; PDR for the Demonstration Test Flight: July 89

This page intentionally left blank.

GLOSSARY

It is useful to define some key terms that will appear throughout the report. "Automation " and "Robotics" are much-used, broad terms. However, the fields of automation and robotics have grown from a blending of many technologies, including computer science, sensors, mechanisms, displays, and controls. Therefore, the terms will have somewhat different meanings depending on the context. For the purposes of this document, we will use the following as working definitions.

Artificial Intelligence: A subfield of computer science concerned with the concepts and methods of symbolic inference by a computer, and with the symbolic representation of the knowledge to be used in making inferences, in order to make a machine behave in ways that humans recognize as "intelligent" behavior in each other.

Automation: The use of machines to control and/or carry out processes in a predefined or modeled set of circumstances without human intervention. Advanced automation, for the purposes of this report, is used to refer to the fields of artificial intelligence, teleoperation, and robotics.

Autonomy: An attribute that allows a system to operate to its specified performance without external intervention for a specified period of time. Fault tolerance and reliability are key features of autonomy.

Expert Systems: A subfield of artificial intelligence concerned with developing computer programs that use knowledge and reasoning techniques in specific problem domains to emulate the decision processes of human experts.

Robotics: The study and use of machines capable of manipulation and/or mobility with some degree of autonomy. The automation may be almost complete – as in the case of an industrial manipulator that follows a sequence of preprogrammed moves, or the Viking Lander that carried out sequences of operations during the periods between instructions – or limited, as with teleoperators used for nuclear or undersea operations.

Teleoperation: The study and use of manipulators that receive instructions from a human operator and perform some action based on those instructions at a location remote from the operator.

Telepresence: Used to describe teleoperation in which the cues available to the operator allow him to feel present at the remote location.

Telerobot: A device that can be viewed as a hybrid between a robot that has a degree of autonomy and a teleoperated device that is under the control of a human operator at all times. " A telerobotic device can be operated by a human, and much of the time must be. However, it incorporates some capability for independent action, typically the execution of simple, repetitive tasks which are part of a long procedure. For example, an operator may control the device through several steps and then come to a point where a set of fasteners needs to be removed. If this removal step has been provided for, the operator can switch the device to the robotic mode, let it remove the fasteners, and then resume control personally when the tedious task has been completed". A telerobot may also be considered to be an intermediate stage in the evolution toward a robot.

This page intentionally left blank.

ACRONYMS

2D, 2-D	Two dimensional
3D, 3-D	Three Dimensional
A/D	Analog to Digital
A&R	Automation and Robotics
Ada	A programming language for developing distributed systems
AANMS	Advanced Automation Network Monitoring System
ACES	Analysis Criteria Evaluation System
ADPE	Advanced Data Processing System
ADS	Advanced Decision Systems
AI	Artificial Intelligence
ARC	Ames Research Center
ART	Automated Reasoning Tool
ASDW	Automated Software Development Workstation
ASSAP	Automated Space Structures Assembly Program
AUTOPROG	Automation Program
AUTOPS	Autonomous vehicle operations testbed
AutoLib	Automated on-line library
C	A programming language
C&T	Communication and Tracking
CAD	Computer Aided Design
CALS	Computer Aided Logistics Support
CANSAS	Connected Autonomous Neural Sight-Arm System
CASE	Computer Aided Software Engineering
CDR	Critical Design Review
CLIPS	C Language Integrated Production System
CLIPSIT CLIPS	Intelligent Tutor
CMS	Control and Monitoring Subsystem
COCOMO	Constructive Cost Model
CONFIG	A system for modeling and engineering of automated systems for FDIR
COSMIC	Computer Software and Management Information Center
CPU	Central Processing Unit
DAP	digital auto pilot
DASHES	Dump Analysis for Simulator/Hardware Expert System
DEU	Display Electronic Unit
DEUCE	Display Electronic Unit Criteria Evaluator
DKC	Design Knowledge Capture
DMS	Data Management System
DOF	Degrees of Freedom
DSP	digital signal processing
EAGOL	Epistemic Abductive Goal Oriented Language,
EMAA	Electromechanical Attenuator/Actuator
ESL	Engineering Script Language
ESFAS	Expert System for Flight Analysis System
ETC	End-to-End Test Capabilities
EVA	Extra Vehicular Activity
EVAR	EVA Retriever

FADS	Flight Analysis Data System
FDDI	Fiber Distributed Data Interface
FDIR	Fault Detection, Isolation, and Recovery
FDO	Flight Dynamics Officer
FIBS	Fault Isolation by Bit Strings
FOE	Flight equipment interface Online Evaluator
FORTRAN	(Formula Translation) A Computer Programming language used in writing scientific and technical programs
FTS	Flight Telerobotic Servicer
GFE	Government Furnished Equipment
GN&C	Guidance, Navigation and Control
GSFC	Goddard Space Flight Center
GTI	A computer
H2	Molecular hydrogen
HART	human roles, automation, robotics, and telerobotics
HLCM	High Level Command Module
I/O	Input and Output
ICAT	Intelligent Computer Aided Training
INCO	Integrated Communications Officer
IPS	Instrument Pointing System
IR	Infra Red
IRIS	A computer made by Silicon Graphics
ISA	Integrated Status Assessment
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
KART	Knowledge Acquisition and Representation Toolkit
KB	Knowledge Base
KSC	Kennedy Space Center
KT	Knowledge Tool
LATEST	Launch Countdown Anomaly using Expert Systems Technology
LaRC	Langley Research Center
Lisp	(List processor) A programming language used for developing application of artificial intelligence
MAAP	Mission Evaluation Room Advanced Automation Project
MCC	Microelectronic and Computer Technology Corporation
MCC	Mission Control Center
MDF	Manipulator Development Facility
MIT	Massachusetts Institute of Technology
MITRE	The MITRE Corporation
MMP	Main Propulsion Pneumatics
MMU	Manned Maneuvering Unit
MOST	Mission Operations Support Technology
MPAD	Mission Planning and Analysis division
MSFC	Manned Space Flight Center
MSIF	Multi-System Integrated Facilities
MSIS	Man Systems Integration Standards

NETS	A programming tool for the building neural networks
NIST	National Institute of Standards and Technology, formerly National Bureau of Standards
O2	Molecular oxygen
OASIS	Operations and Science Instrument Support
OAST	Office of Aeronautics and Space Technology
OBS	On-Board Systems
OMA	Operation Management Application
OMV	orbital maneuvering vehicle
ONAV	Orbital navigation
OOS	Orbital Operations Simulation
OSF	Office of Space Flight
OSS	Office of Space Stations
OSSA	Office of Space Science and Applications
OSU	Ohio State University
PAM	Payload Assist Module
PC	Personal Computer
PCEE	Portable Common Execution Environment
PCLIPS	Parallel CLIPS
PD/ICAT ICAT	system for training in PAM Deploys
PDR	Preliminary Design Review
PDRS	Payload Deployment and Retrieval System
PIDA	Payload Installation and Deployment Aid
POR	Point of Reference
QUEST	Quality Expert System Tool
R&D	Research and Development
R&T	Research and Technology
RENEX	Rendezvous and Navigation Expert System
REX	Rendezvous Expert System
RMS	Remote Manipulator System
RTOP	Research and Technology Objectives and Plan
SBC	Single Board Computer
SBIR	Small Business Innovative Research
SDF	Synthetic Discriminant Filter
SERC	Software Engineering Research Center
SES	Systems Engineering Simulator
SHADES	Shuttle AP-101 Diagnostic Expert System
SILES	Shuttle I-Load Expert System
SLCSE	Software Life Cycle Support Environment
SMAP	Software Management and Assurance Program
SPARC	Second generation workstations made by Sun Microsystems
SPF	Software Production Facility
SS	Space Station
SSE	Software Support Environment
SSFP	Space Station Freedom Program
SSFP	Space Station Freedom Program
SSME	Space Shuttle Main Engine
STS	Space Transportation System
SUN	A computer workstation made by Sun Microsystems

T&O	Test and Operations
TBD	To be determined
TEXSYS	Thermal Expert System
TI	Texas Instruments
TRAC	Targeting and Reflecting Alignment Concept
UNIX	A computer operating system
USE	User Support Environment
VAX	A computer made by Digital Equipment Corporation
WP-2	Work Package 2

REFERENCES

JSC1989. Machine Intelligence and Robotics at Johnson Space Center, JSC-23518, September 1989. 2 volumes

This page intentionally left blank.

INDEX OF PROJECTS

Title	Division Code	State*	Page
3-D Laser Vision Processor	EE		49
ACES – Analysis Criteria Evaluation System	EK		63
AI Section/Man-Machine Interfaces	PT		219
AI Systems for Monitoring and Control	ER		91
A Neural Network Based Technique for IR Spectral Analysis	PT	low level	228
A Unified Robotics Control System Using a Parallel CLIPS Environment	PT		208
Active Thermal Control System – Simulation and Fault Management	ER		115
Adaptive Fuzzy Logic Control	PT		202
Advanced Automation Methodology Project	ER		109
Advanced Automation Network Monitoring System	ER		111
Advanced Development for Space Robotics	ER		101
Advanced Force/Torque Control Study for the RMS System	ER		77
Advanced Graphics Laboratory Systems Development	ER	completed	133
Algorithm for Using Multiple Manipulator Arms to Control a Payload.	ER	completed	157
An Accelerated Method for Back Propogation Networks	PT		231
An Automatic Assistant for Scheduling and Planning for the Space Station	PT		226
An Intelligent Mobile Research Robot	ER	discontinued	129
An Intelligent Tutoring System for High School Physics	PT		197
Architectures for Semi-Autonomous Planning	ER		89
Artificial Intelligence and Robotics Flight Safety	NS	low level	179
Artificial Intelligence and Robotics Ground Safety	NS	low level	178

Title	Division Code	State*	Page
AutoLib (Automated on-line Library)	PT		188
Automated Antenna Management	EE	low level	51
Automated Fault Isolation by Bit Strings	EE	low level	50
Automated Grappling Control for the Shuttle RMS	PT		205
Automated Ground Systems Status/Control	DJ		35
Automated Resource Manager	EE	low level	52
Automated Robotic Assembly of Space Station	ER		89
Automated Software Development Workstation (ASDW) Phase II	PT		184
Automatic Scheduling Using A Genetic Algorithm Approach	PT		223
Automatic Perception for NASA Mission Planning and Flight Control	PT		213
Automation Test Bed	EK	inactive	66
Automation and Expert System Applications for Planning and Scheduling	PT		204
Autonomous Lander for Planetary Exploration	ER		95
Autonomous Object Recognition for the EVA Retriever	PT	inactive	245
A Back Propogation Simulator for the Hypercube	PT		229
Biodynamic Checklist Processing	SP		254
Black Board Architecture Shell	ER	low level	160
C Language Integrated Production System (CLIPS)	PT	in use	217
CLIPS Intelligent Tutor (CLIPSIT)	PT		215

Title	Division Code	State*	Page
CONFIG: Qualitative and Discrete Event Fault Management Analysis Tools	ER		105
Collision-Free Path Planning/Robotics Software Test Bed Architecture	ER		143
Computer Aided Software Engineering (CASE) Tools Review and Evaluation	PT		186
Computer Graphics Testbed for Vision Systems to be Used in Space	PT		207
Connected Autonomous Neural Sight-Arm System (CANSAS)	ER		162
Control Architecture for Autonomous Robotics	ER	discontinued	151
Control System Use of Optical Correlator Vision	EE		55
Cooperating Expert Systems	PT		193
Cooperative Agreement with MCC	PT		191
Correlation-Based Synthetic Discriminant Filter for Image Segmentation	PT		227
DASHES – Dump Analysis for Simulator/Hardware Expert System	EK		64
Definition of Advanced Automation Testbed Requirements	ER	completed	147
Demonstration of Magnetic Attachment Tool and Magnetic End Effector	IA		169
Demonstration of a 3D Vision Algorithm for Space Applications	PT		227
Design Knowledge Capture	ER		87
Develop Neural Network Computer System	PT		221
Development and Experimentation of Eye/Brain/Task Test Bed	PT	completed	249
Development of an Ada-Based Version of ART	PT		201
Dexterous Manipulator Demonstration Flight Experiment	IA	in use	169
Diagnostic Reasoner/Recovery Expert	ER		113

Title	Division Code	State*	Page
A Difference Optimized Training Scheme for the Neocognitron	PT	low level	233
Dual Actuator Robotic Joint Mechanism	ER		76
Dynamic Modeling of 6+ DOF Robotic Manipulator Systems	ER		84
EVA Retriever Central Software	ER		149
EVA Retriever Ground Demonstration	ER		99
EVA Retriever Test Bed	ER		121
EVA Retriever Vision/Tracking System	ER		127
Electrolysis Fault Diagnosis Expert System	ER		161
Enhancement of Simulation/Animation Graphics System	ER	completed	134
Expert System for Execution of Crew Procedures	ER		103
Expert System for Shuttle Electrical Power Management	PT	inactive	247
FTS/WP-2 Accomodations Issues Task	EC		42
Fault Tolerant Manipulator and Proof of Concept	ER		123
Free-Flyer/Fault Detection and Correction System	ER		119
Free-Flyer/Robotic Arm Positioning Techniques	ER		117
Functional Area Manager for Design Knowledge Capture	ER	in 190-53	142
Functional Area Manager for Work Package 2 Advanced Automation	ER		114
Fuzzy Ring Network for Machine Vision	PT		232

Title	Division Code	State*	Page
General Purpose Development Environment for ICAT Systems	PT		195
Greyscale Morphology in Machine Vision	PT	completed	240
Hardware-in-the-Loop Simulation	ER	low level	130
Helmet Mounted Display System	ER		132
Historical Software Development Cost Data Base	PT		187
Human Interface with Intelligent Fault Management Systems	ER		107
Hybrid Vision Laboratory	EE	inactive	56
Image Remapping	EE		47
Instrument Pointing System/Intelligent Computer Aided Training System	PT		199
Intelligent Assistants Technology -- Human Interface Guidelines	ER		108
Intelligent Computer-Aided Training (ICAT)	PT	in 190-79	237
Intelligent Computer Aided Training System for PAM Deploys	PT	in 190-79	235
Intelligent Evaluation System for Simulator Training	PT		198
Interface to Advanced Display, Control, and Computer Technologies	SP		253
LATEST – Launch Countdown Anomaly using Expert Systems Technology	EK		65
Long Reach Latch Development	ES	inactive	165

Title	Division Code	State*	Page
Machine Vision using Artificial Neural Network Simulations	PT		206
Main Propulsion Pneumatics/Intelligent Computer-Aided Training System	PT		242
Man and Robot Motion Modeling	SP	in use	259
Mission Evaluation Room Advanced Automation Project (MAAP)	ER		135
Model and Simulation for FTS Control Station Testbed and Brassboard	ER	low level	159
Multi-arm Robot Control Environment	ER	low level	85
NETS: A Tool for the Development and Delivery of Neural Networks	PT	low level	242
Neural Network Simulation on Class VI Computers	PT	low level	238
On-Board Navigation Expert System	PT		225
On-Orbit Maintenance	DE	low level	25
Operations Process Model	DA		23
Operator Cognitive Modeling	SP		257
Orbiter and Space Station Control Station Breadboard	ER		128
Override Demonstration	ER	discontinued	131
The Parametric Avalanch Control Module Prototype Development	PT		203
Payload-Assist Module Deploy/Intelligent Computer-Aided Training System	PT		211
Payload Installation and Deployment Aid (PIDA)	ES	low level	167
Phoneme Based Speech Recognition for Mission Planning and Control	PT		183

Title	Division Code	State*	Page
Planetary Surface Systems HART Systems Engineering Studies	ER		82
Procedural Reasoning System	ER	discontinued	158
Programmable 3D Range/Doppler Imagine Ladar	EE		48
QUEST – Quality Expert System Tool	EK	low level, in use	61
RDIA – Requirements Decision Impact Assessment	EK	discontinued, in use	71
RMS Advanced Closed Loop Control	ER		97
Real-Time Garbage Collection	EK	inactive	67
Redundant Manipulator Kinematics	ER		83
Remapping for Low Vision	EE		57
Resource Planning and Management Expert System	PT	discontinued	243
Robot Path Planning Using Genetic Algorithms	PT		239
Robotic Arms for Manipulating Equipment During Thermal Vacuum Tests	ER	inactive	145
Robotic Gripper Controller Development	ER	in use	75
Robotic Vision/Tracking Sensors	ER		125
Robotics Research Arm Advanced Controller Implementation	ER		78
SERC/PCEE	PT		192
SHADES – Shuttle AP-101 Diagnostic Expert System	EK	inactive	69
Shuttle INCO Expert System/Real Time Data System	DF	in use	29
SILES – Shuttle I-Load Expert System	EK	inactive	68

Title	Division Code	State*	Page
SIM Tool	PT		189
Simulation of Robotics Space Operations	ER	in 190-41	144
Smart Electromechanical Attenuator/Actuator for SS Docking/Berthing	ER	discontinued	137
Smart Robotic Hand for EVA Operations	ER		116
Software Cost Modeling and Automated Data Collection	PT	operational	194
Software Life Cycle Support Environment (SLCSE) Beta Test	PT		185
Software Reengineering/Reuse	PT		190
Space Station Assembly Task Identification and Assessment	EC		43
Space Station Health Exercise Monitoring and Control System	ER		93
Space Station Mission Requirements Data Bases	PT	inactive	246
Space Station Operations Management System	ER		79
Space Station Program Human-Computer Interface Guide and Standards	SP		255
Space Station Workstation System	SP		256
Spatiotemporal Neural Network Systems	PT		244
SPLINTER – SpaceLab Integration	EK	discontinued	70
Structural Assembly, Berthing, and Manufacturing Support	ER	inactive	141
Support Technologies Development	PT		209
System Management Applications	DH		31
Task Level Robot Programming for EVA Retriever Simulation	ER	discontinued	153
Telerobotic Servicer Man-Systems Integration and Testing	SP	discontinued	261

Title	Division Code	State*	Page
Telerobotics Flight Experiment Definition	IC	inactive	176
Thermal Expert System (TEXSYS) for Control and Fault Diagnosis	EC	completed	44
Transition Flight Control Room Enhancement	DJ		35
The Use of Fuzzy Set Theory in Controlling Failures in Space Systems	PT	completed	241
Verification and Validation of Rule Based Systems	ER	in 190-84	139
Vision for Grasping for EVA Retriever	ER	discontinued	156
Vision for the EVA Retriever	ER		155

* If no state is given, the project is active.

*U.S.GOVERNMENT PRINTING OFFICE:1990-561-057/20077